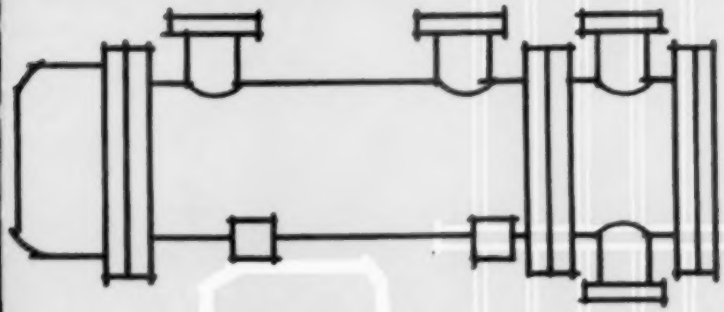
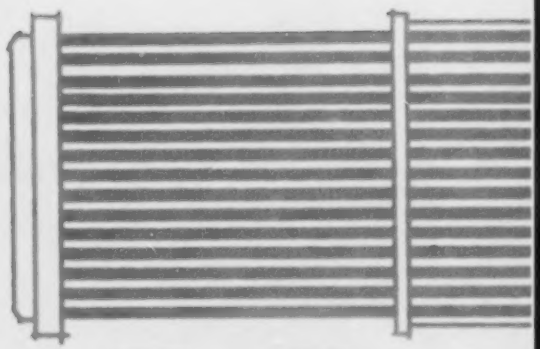
Petroleum Processing

PETROLEUM REFINING | PETROCHEMICAL MANUFACTURING | GAS LIQUIDS RECOVERY

MARCH, 1956





A Special 32-page Report on HEAT EXCHANGERS—p. 101

PLUS 80 PAGES of your regular editorial menu, including . . .

A LONG LOOK AHEAD—What product demand will be in 1965 . . . . p. 63

PAY THE RIGHT TAX—Help in making out personal income return . . p. 70

TRAY DESIGN BASICS—Part 2 in a new design manual for you . . . p. 82

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The **FOX Gas Processing Plant** was designed and constructed by Hudson in collaboration with Signal Oil and Gas Company. The plant design includes features reflecting a combination of the long experience of Signal in the operation of similar plants with the experience of Hudson in designing, constructing and initially operating more than 100 major projects for the oil and gas industry.

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Reader's Guide

What's New in Petroleum

An EXTRA this Month

Special 32-page PETROLEUM PROCESSING Report:

Heat Exchangers

- **What they are**
- **How they are made**
- **How to design them**
- **Where they are used**
- **How to handle them**
- **How much they cost**

ONE OF THE MOST IMPORTANT PIECES OF EQUIPMENT in any petroleum processing plant—refinery, petrochemical operation, or gas liquids recovery—is the heat exchanger. It's hard to find a process which doesn't use heat exchangers. It's just as hard to find a process that couldn't benefit from better heat exchanger selection and design.

HERE, IN SIMPLE, CLEAR, and READABLE LANGUAGE, are some of the things you should know about heat exchangers to understand them better and to use them better.

YOU WILL NOT BECOME AN EXPERT on heat exchangers. This report will not tell you everything you need for that purpose. But, it will clear up a lot of questions for the engineer who has to deal with the equipment without being an expert.

THIS REPORT IS OF INTEREST "across-the-board," regardless of your specific job responsibility or branch of the industry. For that reason, we have not used the usual code system this contents page provides for indicating the particular field each article covers. **Turn to p. 101**

A McGRAW-HILL PUBLICATION

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Processing for March, 1956

I II III 1 2 3 4 5

A Long, Long Look Ahead

By 1965, U.S. refiners will have to meet a daily product demand of 12.8-million bbl; and they will be doing it with about 12.6-million b/d capacity, with imports up. For further details see p. 63

I III 3 5

Need a Smokeless Flare?

Here's a system that's working, and working well. It was installed a year ago in the Oleum refinery of Union Oil Co. of California. Including both a pit and a flare stack, it handles large emergency flows. By J. R. Hannaman and A. J. Etingen. p. 66

I 2 3 4

Paying the Right Income Tax?

Helpful tips for filling out your own return, with answers to such questions as: what is taxable income? what deductions are allowed and what are not allowed? By Eli Gerver, staff member, American Association of Accountants. p. 70

I II III 1 2 3 4 5

Montreal—Big Processing Center

Five refineries – 240,000 b/d capacity – over one-third of all Canada's 1956 total capacity – these are the facts. What made Montreal that way? Are things done differently? What of the future? How about petrochemicals? A 10-page report. p. 72

I II 3 5

I II III 1 2 3 4 5

Bubble-Cap Tray Design—Part II

The first truly complete manual of new process design methods for optimum bubble-cap tray design. The second of a four-part series, prepared exclusively for you, by W. L. Bolles, Monsanto Chemical Co.

In this month's installment, Mr. Bolles discusses every factor in design—including construction materials, general types of trays, downcomers, weirs, cap pitch, spacing, skirt height, etc. p. 82

I II III 2 4

You Can't Beat Good Feedwater

. . . for lowering boiler maintenance costs. This system at Lion Oil Co., El Dorado, Ark., as described by mechanical superintendent J. B. Adams, has eliminated corrosion, scale, and other headaches for the past two years. p. 96

I II 3 4

NEW

"Targets" for Refiners' Stocks

New in your Operating Trends, starting this month, are bull's-eyes showing adequate stocks at critical dates ahead. Another "new" is a forecast of crude runs and product demand, monthly instead of by quarters, making comparisons easier. p. 177

I III 3 5

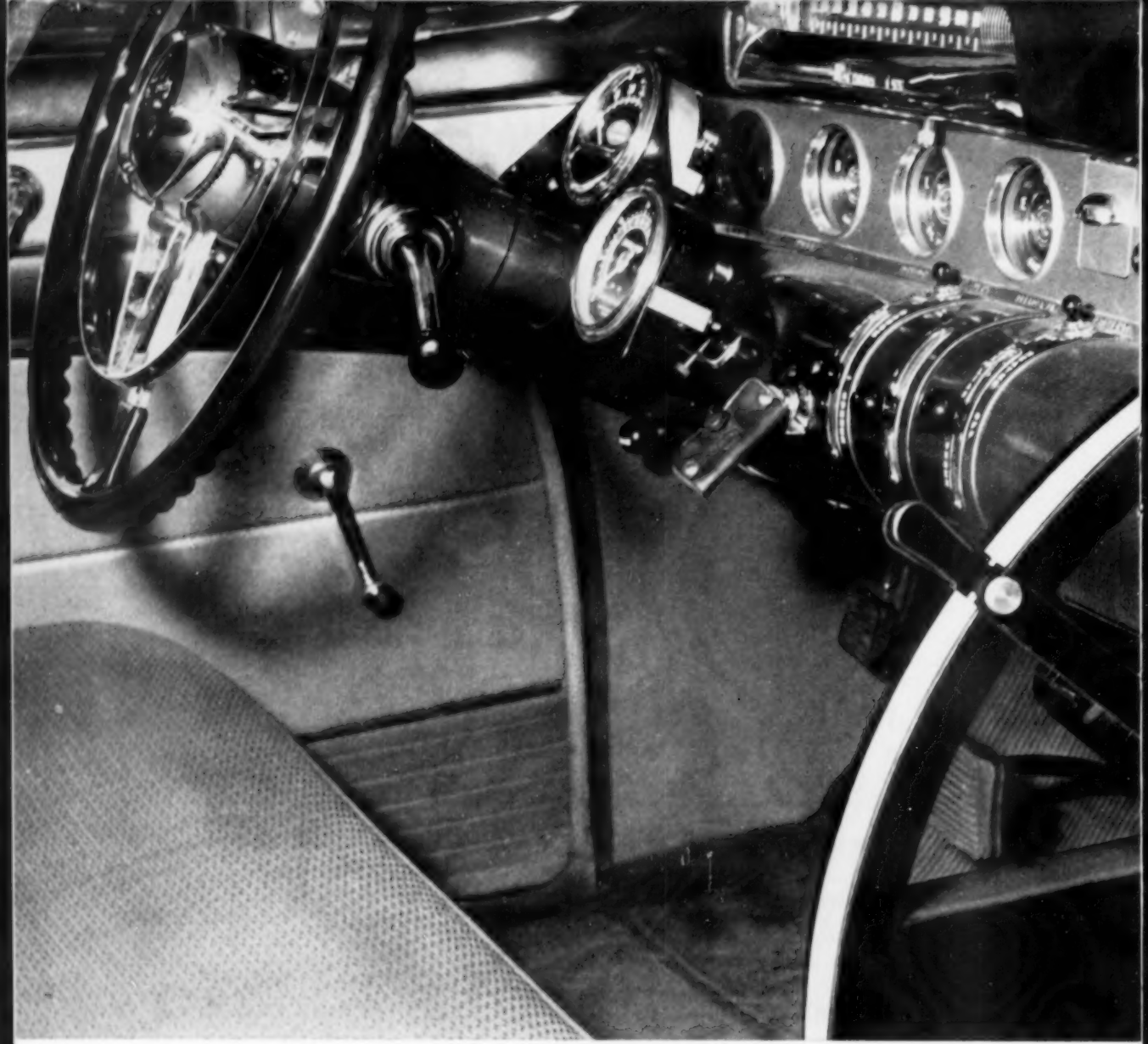
DEPARTMENTS

Publisher's Page	7	Patents	163
What's Happening	9	Meetings	167
Tomorrow	15	Books	171
Process Data Sheet	137	Operating Trends	177
Plant Practices	141	Information Offered	180
New Words	147	Advertisers' Index	183
Engineering Data Sheet	149	Readers' Service Card	185
Personals	153	What's New	185
Suppliers	159	Editorials	320

Continue "Readers' Guide" on p. 133

HOW TO USE IT:

Your new "Reader's Guide to What's New in PETROLEUM PROCESSING" will do two things for you. First, the key numbers with each article will tell you at a glance if it is within your scope of interest; Roman Numerals indicate industries; Arabic Numerals, fields of activity. Second, the longer descriptions will tell you what each article is about, and why it can be of help and interest to you. —The Editors



Above, test car with minimum instrumentation needed for fuel rating.

How Ethyl Research equips a car for accurate fuel ratings

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Our people have accumulated hundreds of thousands of miles of road testing experience with this equipment. If you would like more

Right, equipment suggested for more complete test-car setup.

information about this subject, please contact your Ethyl technical representative.

INSTRUMENTS SHOWN in this advertisement have proved satisfactory in Ethyl test cars but are not necessarily endorsed by Ethyl Corporation. Although the products of some specific manufacturers are shown, several of the instruments are made by various companies, and we'd be glad to mail you a list of sources. Just send your request to Box 13, Ethyl Corporation, 100 Park Avenue, New York, N.Y.

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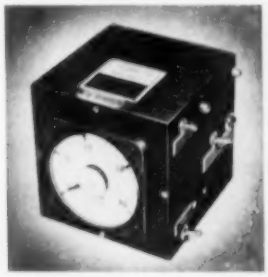
Electronic spark protractor provides an accurate method for continuous indication of spark advance. It gives direct readings at all speeds.

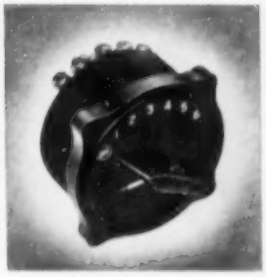
Timing light (above), calibrated flywheel and sight tube are used for obtaining instantaneous spark advance position. Flywheel is marked in crankshaft degrees.

Auxiliary fuel system facilitates testing of several fuels in succession. Simple coupling connects the auxiliary line to the inlet side of the fuel pump.

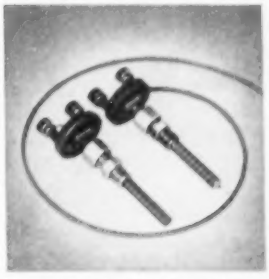


Tachometers are accurate mechanisms for measuring the engine speed. They are adaptable for operation with any six- or twelve-volt system.

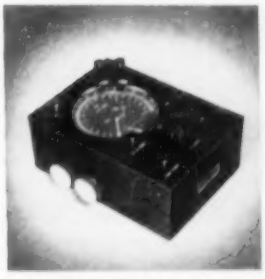
Vacuum gauge is required for part-throttle ratings. At any given car speed, the vacuum gauge permits reproducing part-load conditions.



Selector switches for thermocouples and resistance bulb thermometers are needed to permit reading temperatures at various locations.



Thermocouples and resistance bulbs are used to measure the temperatures of the coolant, the lubricating oil, and the air entering the carburetor.



Potentiometer is used to indicate the temperatures measured by the thermocouples. Road ratings require a rugged instrument, insensitive to vibration.

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(To obtain more data on advertised products see page 182)

Petroleum Processing

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Publisher's Page

Not for the Heat Exchanger Expert

REMEMBER last August? I promised you then that you'd be getting more of PETROLEUM PROCESSING's Special Reports, like the one on "An Appraisal of Catalytic Reforming."

Well, the next one is in this issue. It deals with Heat Exchangers, and you'll find it on pp. 101-132. This report was written for us and at our request by an expert in the field—Daniel Donohue. Dan is the engineer in charge of all of Chemical Construction Co.'s heat exchanger work. He's a chemical engineer (Brooklyn Polytech, 1931—plus an M.A. in chemistry from Columbia, 1933), but he has concentrated on heat exchanger design for the past 19 years. He spent four years with Griscom-Russell, 10 with Lummus, and has been with Chemical Construction since 1952. He even teaches a course in Heat Transfer in the Evening Graduate School of Brooklyn Poly.

Don has designed all kinds and sizes of exchangers—from a baby with a single foot of heat transfer area for a laboratory packaging unit, to one with 4000 sq. ft. of surface for a new catalytic reformer now being designed for a major east coast refiner.

When we outlined our plans for this Special Report to Dan last June, we told him we didn't want an article for the expert. We wanted a piece that could be read and understood by the 95% of our readers who don't have to be experts on heat exchangers—but who do have to work with them and want to know more about them.

We wanted a piece that would explain the different types of exchangers, the major characteristics of each, some of the highlights of their design (both process and mechanical), which ones to use for various jobs, and how to estimate costs quickly.

In short, we wanted a good, practical report—the kind that would answer the everyday questions that you have on heat exchangers. And that's the kind of a report Dan put together for us. It's one I'm sure you'll find very useful—and well worth saving.

William F. Bland

—Editor

P.S. There's one little feature about these Special Reports which maybe I shouldn't point out to you—except that you're smart enough to figure it out for yourself sooner or later anyway. They are completely self-contained. If you don't mind ripping your March copy of PETROLEUM PROCESSING to pieces, simply remove the two staples that hold the entire issue together, and you'll be able to pull out the report intact. Of course, if you object to mistreating PETROLEUM PROCESSING in that manner, we've got reprints available. How to get one is told on pg. 184.

Other McGraw-Hill Petroleum Publications

National Petroleum News
The monthly magazine of oil marketing—news, prices, transportation, storage merchandising

Platt's Oilgram News Service
A daily independent oil-news reporting service issued from New York, Chicago, Houston

Platt's Oilgram Price Service
A daily independent oil-price reporting service issued from New York, Chicago, Houston

Petroleum Week
The industry-wide magazine—covering production, processing, transportation, marketing

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Some liquids need to be "terminalled" in tanks of aluminum—some in stainless steel. Some must be kept warm with heating coils—some require refrigeration. Special valves and pumps must be designed to handle many of these liquids. Above all, you need the knowledge and experience of experts, especially for "ticklish" chemicals. General American has both facilities and personnel—available to you on an advantageous lease basis.

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What's Happening

in Refining

. . . **Two Standard Oil Co. (N.J.)** affiliates will build fixed-bed cat reformers using Esso Research & Engrg. Co.'s new "Powerforming" process. A 20,000 b/d unit will go into Esso Standard Oil's, Rahway, N. J., refinery, and an 8000 b/d unit into Imperial Oil Ltd., Montreal, Que.

. . . **Standard Oil Co. of Texas** will expand its El Paso refinery to 61,000 b/d output from its present 36,000 b/d, at an estimated $18-million, with completion scheduled for Sept., 1957. New units will include Fluid cracking, vacuum flasher, poly plant, and vapor recovery of undisclosed size; and a 25,000 b/d crude still.

. . . **Sinclair Refining Co.** plans a $1.3-million "hydrofinishing" unit, using catalytic reformer hydrogen for lube oil finishing, at East Chicago, Ind., with completion late this year.

. . . **Standard Oil Co. (Ohio)** plans a "substantial expansion" in refining capacity. No decisions have yet been made on location, specific design, or an appropriation.

. . . **Standard Oil Co. (Indiana)** starts building a new four-unit lube oil plant at Casper, Wyo., this summer, with completion planned for May, 1957. Units include 4800 b/d vacuum pipe still, 1000 b/d propane deasphalting, 1500 b/d furfural extraction, and 2000 b/d MEK dewaxing and deoiling. Foster Wheeler is the general contractor.

. . . **Commerce Oil Refining Corp.** has cleared last legal obstacle, expects to break ground about middle of April for 30,000 b/d refinery at Portsmouth, R. I.

. . . **The Texas Co.** has started negotiations for the purchase of 600 to 700 acres of waterfront property at Anacortes, Wash., for a new 30,000 b/d refinery. Hope is to start construction late this summer.

. . . **New construction projects underway,** as indicated by recent fast tax write-off approvals:

Straits Refining Co., $26.4-million, 10,000 b/d new refinery in Puget Sound area of Washington.

Continental Oil Co., $995,652, for 6270 b/d catalytic reformer and hydrodesulfurization unit at Billings, Mont.

Phillips Chemical Co., $12.5-million on new plant facilities at Sweeney, Tex.

Pontiac Eastern Corp., $18.1-million on new 10,000 b/d refinery in Lamar and Forest counties, Miss.

Phillips Petroleum Co., $163,245 on gasoline plant expansion, Etter, Texas.

American Oil Co., $946,000 on modification and expansion of cat cracking and reforming, Texas City.

D-X Sunray Oil Co., $199,000 on cat cracker expansion at Duncan, Okla.

Phillips Petroleum Co., $611,000 on natural gasoline units, Andrews County, Tex.

The Texas Co., $3,600,000 on new refining facilities at Casper, Wyo.

Contracts awarded recently

. . . **U. S. Oil & Refining Co.,** to J. B. Gill Co. of Long Beach, Calif., for combination topping and thermal cracking unit, vacuum still, and UOP catalytic polymerization unit at new 6000 to 7000 b/d refinery at Tacoma, Wash.

. . . **Socony Mobil Oil Co.,** to Fluor Corp. for new 12,000 b/d Sovaformer catalytic reformer at East St. Louis, Ill., including a 16,000 b/d pretreater, with completion set for early 1957.

. . . **Imperial Oil Ltd.,** to Fluor Corp. of Canada, for 8000 b/d cat reformer at Sarnia, Ont.

. . . **Socony Mobil Oil Co. Inc.,** to Foster Wheeler Co. for a 22,000 b/d catalytic hydrodesulfurization unit at Paulsboro, N. J., with completion in March, 1957.

. . . **British American Oil Co.,** to Lummus Co., Canada, Ltd., for a $4-million, 10,000 b/d catalytic reformer at Clarkson, Ont., with completion early 1957.

Recent completions

. . . **Excelsior Refineries Ltd.,** 2000 b/d, at end of February, the fifth refinery in British Columbia, at Dawson Creek, in the Peace River area.

. . . **Standard Oil Co. of British Columbia Ltd.,** a new 2750 b/d Platforming unit, first in B.C., fifth in Canada.

in Petrochemicals

. . . **Cosden Petroleum Corp.** has awarded construction contract to Badger Mfg. Corp. for a 20-million lb/yr., $3-million styrene unit at Big Spring, Tex., with completion scheduled for December, 1956.

. . . **Esso Standard Oil Co.** has revealed it will build its long-expected ethylene plant at Linden, N. J., though not until late 1956 or in 1957. Details on size or other plans have not been completed. Process to be used is reported to be a low-temperature, high pressure process. Meanwhile, Esso will start building another ethylene plant at Baton Rouge, La., in May. Details have not been disclosed, though the investment is understood to be about $12-million.

. . . **Dow Chemical Co.** will add 30-million lb/yr of ethylene oxide capacity at Freeport, Tex., by late 1956.

This boost is in addition to a 60-million lb/yr increase in ethylene oxide-glycol capacity at the same site announced late last year.

. . . **Phillips Pacific Chemical Co.** has purchased 200 acres in southeastern Washington, 7 miles southeast of Kennewick on the Columbia River, where it will begin construction this spring of its 200 ton/day ammonia plant, with completion late in 1956. Hydrocarbon Construction Corp. has contract.

. . . **Rohm & Haas Co.** is reported to be planning an acetylene-from-natural-gas plant in Deer Park, Tex. No details have yet been disclosed, but it is believed facility will be around 20-million lb/yr in size, and represent $10-million investment.

. . . **Arkansas Louisiana Gas Co.** may be next gas firm to get into petrochemicals. Company is making evaluation studies now on potentiality. Indications are facilities would be located near its Columbia, Ark., natural gasoline plant, which can process 100-million cfd of gas.

. . . **Monsanto Chemical Co.** is building an adipic acid unit at its Lion Oil operations in Luling, La. Exact cost was not disclosed, but was said to be several million dollars. Completion is planned for early 1957.

. . . **Imperial Oil Ltd.** has started construction at Sarnia, Ont., of a $38-million plant to turn out 30-million lb/yr of dodecyl benzene and smaller quantities of other alkyl aromatics. Sarnia will also produce tri-and tetra-propylene.

. . . **Carbide and Carbon Chemicals Co.** is adding capacity for another 65-million lb/yr of ethylene glycol at Seadrift, Texas, with completion by fall.

. . . **Hercules Powder Co.** has begun construction of its new $6-million, pentaerythritol plant at Louisiana, Mo., with completion early in 1957, and annual production rates of 24-million lb. of pentaerythritol and 100-million lb. of formaldehyde.

. . . **Escambia Bay Chemical Corp.'s** new ammonia and nitrogen fertilizers plant at Pensacola, Fla., went onstream in January. Initial production rate of 75 ton/day of ammonia will soon hit rated capacity of 200 ton-day.

in Foreign Operations

. . . **Latin-American activities:**

Standard Oil Co. of California is considering a $40-million refinery at Colon, Panama.

National Petroleum Corp. of Cuba, newly organized by two Florida men and Cuban interests, plans a $10-million, 5000 b/d refinery at Cienfuegos, a port on the Caribbean.

Glenn McCarthy's proposed 3000 b/d refinery at Concepción, Paraguay, and crude line from Bolivia to the plant, a $10-million investment, has been approved by the government of Paraguay.

. . . **Britain and Europe:**

British Petroleum Co. will expand its 90,000 b/d Kent refinery on Isle of Grain to about 140,000 b/d, for about $55-million, completion by 1957-58.

Les Produits Chimiques de Persan, new French firm, will make lube and fuel additives.

Stanic (Jersey Standard and ANIC of Italy) will build 5600 b/d platinum type cat reformer at Bari.

First UOP Platformer in Italy now onstream at Porto Marghera, a 1500 b/d unit, at refinery owned by British Petroleum and AGIP.

Naphtachimie has awarded contract to Scientific Design for adding direct oxidation (see PP, Nov. 1955, pp. 1763-5) ethylene unit at Lavera, near Marseilles. When finished in mid-1957, unit will nearly double existing capacity of 8000 ton/yr.

British Petroleum Chemicals Ltd. has changed its name to British Hydrocarbon Chemicals Ltd.

. . . **in the East:**

Syria is seeking bids on construction of a 15,000 b/d refinery from free-world firms after a "bargain price" offer from Soviet Russia. Syria has established a government Office of Oil Refining, capitalized initially for about $3-million.

Kuwait Oil Co.'s soon-to-start expansion project at Mina Al Ahmadi to raise capacity to 190,000 b/d from present 30,000, will be finished near end of 1957. Units include two 80,000 b/d crude stills. Contracts are held by E. B. Badger & Sons Ltd., and Bechtel International Corp. in association with George Wimpey and Co. Ltd.

Arabian American Oil Co. is adding 15,000 b/d hydrofiner at Ras Tanura, Saudi Arabia, for $4.1-million. Lummus Co. is building; completion will be spring, 1957.

Standard-Vacuum Oil Co. has awarded contracts for Fluid cracker, cat poly and other units in $20-million modernization at Sungei Gerong, near Palembang, Indonesia. Foster Wheeler will build 11,000 b/d Fluid unit and 1200 b/d cat poly unit.

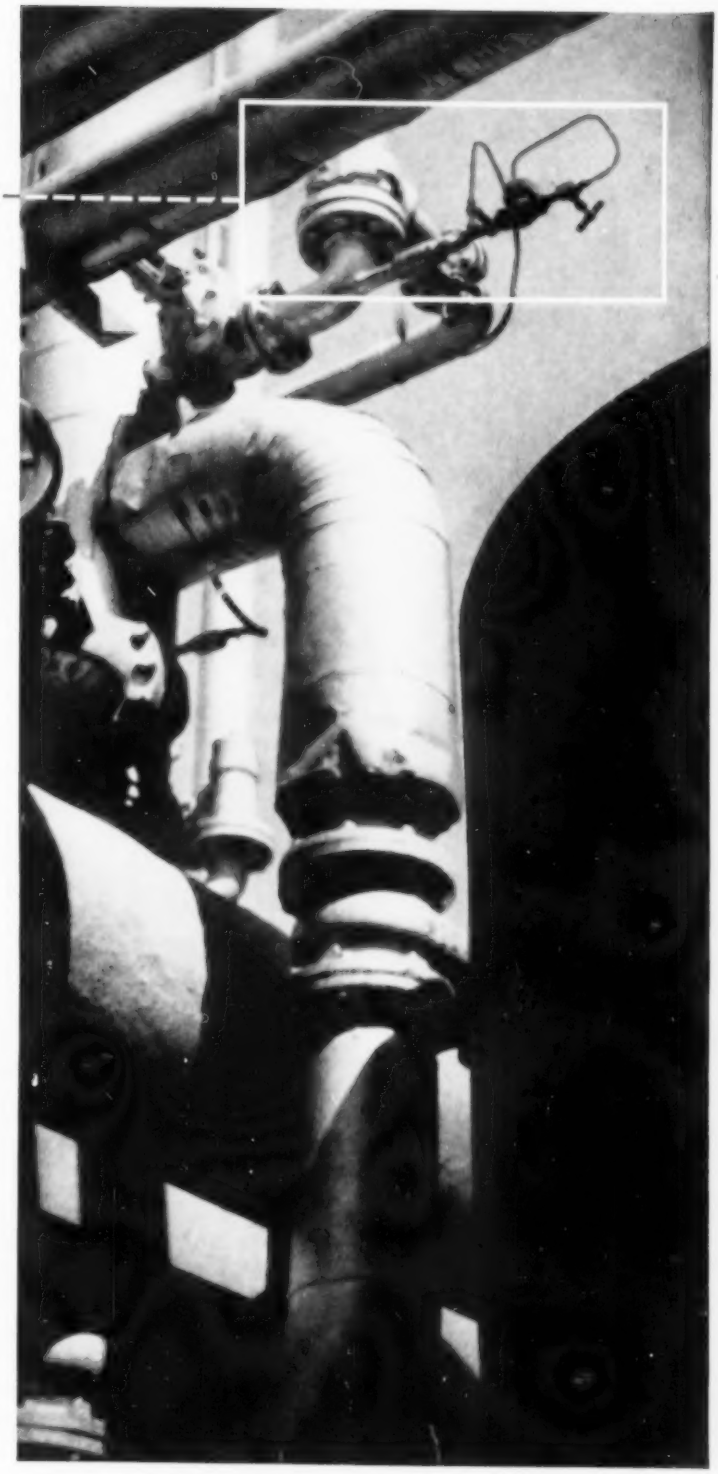
Fertilizers & Chemicals Ltd., Haifa, Israel, plans 15,000 ton/yr ammonia-from-natural gas plant at Heletz.

in Markets and Prices

. . . **Under the impact of continued heavy demand,** prices in primary markets edged higher in February, with the spotlight focused on West Coast heavy fuel and the comeback in Pennsylvania-grade crude prices. In products markets, heavy fuel and distillates were steady to higher, and lube oils advanced 2 to 3.5¢ per gal. generally.

Against background of residual fuel shortage on the West Coast, California heavy crude prices were boosted between 1 and 5¢/bbl for gravities below 26. In-

LIFELINE FOR A REFINERY



This thin loop of copper tubing is the mark of a refinery that has learned to combat corrosion and fouling the modern Polyrad way. This is the injection line for Polyrad—and it can well be called the "lifeline" for refinery equipment.

Polyrad is a filming amine that acts both as an inhibitor and detergent. Its detergency maintains throughput, increases heat transfer, and cuts down time for maintenance. At turn-around time you really see the difference—Polyrad—protected bundles are free of corrosion, ready for immediate return to service.

Stocks of Polyrad are maintained throughout the country. A Hercules trained representative will be glad to discuss its application to your specific operating conditions.

Pine Chemicals Division, Naval Stores Department

HERCULES POWDER COMPANY

984 King Street, Wilmington 99, Del.

POLYRAD®

FILMING AMINE INHIBITOR

(To obtain more data on advertised products see page 182)

creases of 10 to 15¢/bbl on heavy fuel then followed.

West Coast residual shortage was pointed up by Armed Services Petroleum Purchasing Agency's report that it is still 1-million bbl. short of its needs for first half of 1956.

With a 15¢/bbl increase posted by South Penn Oil in prices it pays for Penn-grade crude, Bradford district oil at $4 was up 87¢/bbl from a low of $3.23 it reached in September, 1954.

. . . **Lube oil prices advanced** in most primary markets. In western Pennsylvania, 25-pour test bright stock was 1¢ higher at 23¢/gal. At the Gulf, bright stock moved up 2 to 5¢, and neutrals were up between 2 and 3.5¢/gal. Same trends were apparent in the Mid-Continent.

With the heating season running colder than normal east of the Rockies, refiners were hard pressed to keep distributors' tanks filled with both light and heavy fuels, especially in the Midwest.

Prices for distillate fuels in the Mid-Continent moved up 0.25¢/ gal, with kerosine quoted upwards from 10.25¢ and No. 2 fuel from 9.25¢, Group 3 basis. Group 3 price for heavy fuel also moved up 5¢. At the Gulf, kerosine was up another 0.125¢.

Looking Ahead

. . . **$115-billion by 1965,** that's what the petroleum industry will spend between now and 1965 to meet the demand of the free world, according to an intensive look into the future just made by the petroleum department of the Chase Manhattan Bank. Among highlights of the study, published late in February:

- Free world demand will rise 74% in next 10 years. Supply will have to be boosted by 71% just to keep pace. The $115-billion needed is more than twice the capital outlays oil has made in the past 10 years.
- Free-world demand will average an estimated 24.8-million b/d by 1965. This compares with 14.3-million b/d in 1955.
- Supply available to the free world by 1965 is estimated at 24.95-million b/d, compared to 14.4-million b/d last year.
- The greatest increases in demand, supply, and capital spending in next 10 years will be in areas outside the U.S.
- Refining's share of the $115-billion is about $20.1-billion. For further details as to the future outlook for refining, turn to page 63.

. . . **A new gas-liquids separation process** is going through final tests by Jefferson Lake Sulphur Co. at its St. Mary Parish, La., gasoline plant. Trade-named the Rotosorber process, it is a dry adsorption method believed to be similar to Sun's Arosorb or Cal Research's cyclic adsorption.

. . . **Another waste disposal wrinkle:** Bankline Oil Co., Bakersfield, Calif., plans to dump its plant waste fluids into an abandoned deep-test hole, an 11,577-ft. wildcat well.

. . . **New shale oil method?** Denver Research Institute will try a new Swedish process, patented by Aspengren & Co., Stockholm, for producing petroleum products from Colorado shale. Target is a cut in current cost of producing shale oil from about 16¢ per gal to a competitive figure of 13¢.

. . . **Concentrate on catalytic reforming capacity.** This was the suggestion by Brig. Gen. W. W. White, chief of the Pentagon's Petroleum Logistics Div., in expressing concern over the refining industry's ability to meet growing jet fuel needs.

Even under peacetime conditions, White sees a demand for up to 410,000 b/d of jet fuel by 1965. War could boost world's jet fuel needs to about 2-million b/d.

. . . **New types of jet fuels on horizon** include boron. The metal, with heat content of 25,120 Btu/lb compared to 19-20,000 Btu/lb in present jet fuels, is under secret research by Vitro Corp. of America.

General Electric, meanwhile, revealed it is studying "hydrocarbons heavier than present range" at its new research center near Cincinnati.

. . . **Butane demand for new butadiene plants** completed, under construction or planned in the Southwest, will probably hit 30,000 b/d during next couple of years.

In Transition

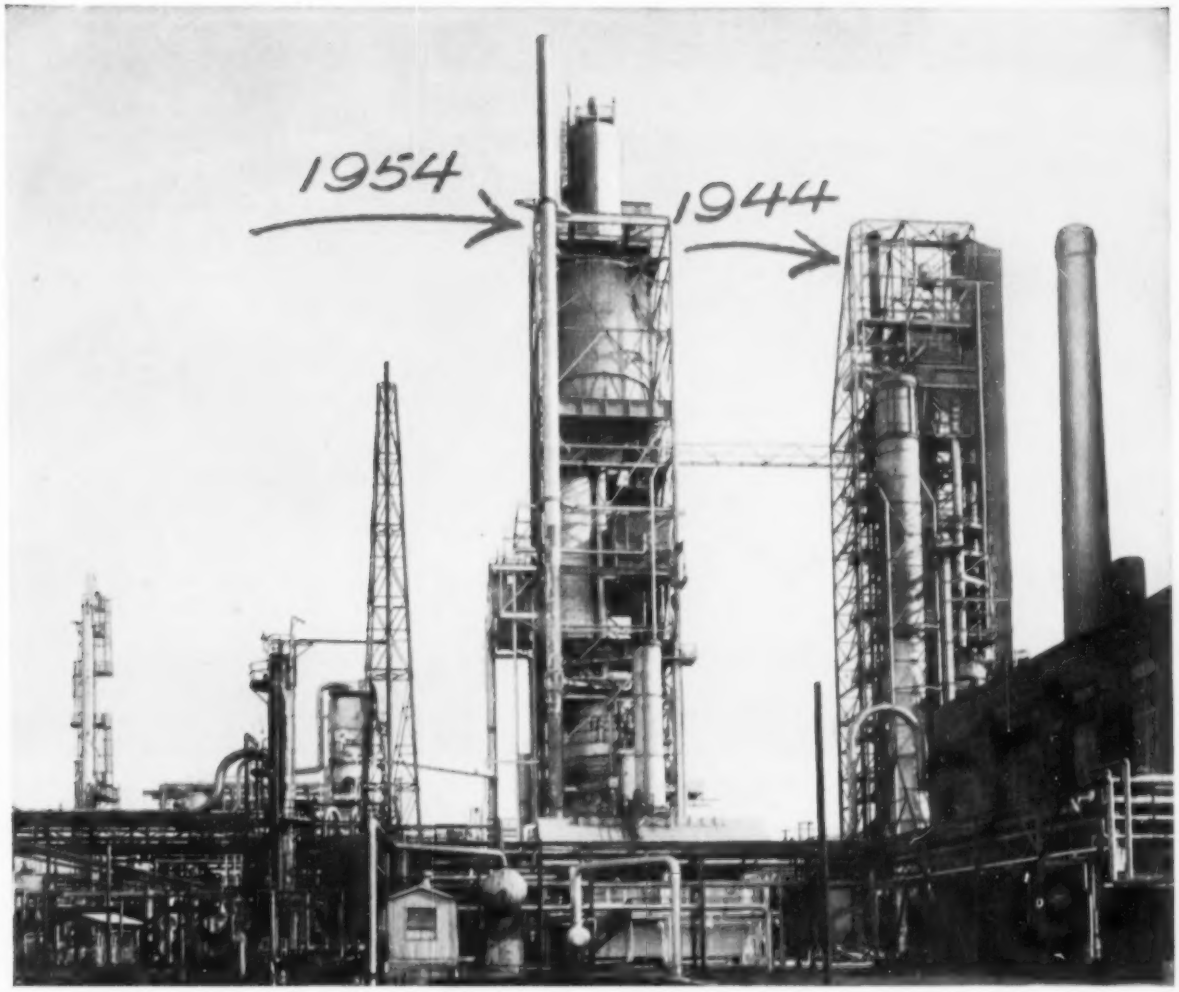
. . . **Goodrich-Gulf Chemicals, Inc.,** was to take possession of the 122,000 ton/yr synthetic rubber plant at Institute, W. Va., in mid-February, barring any veto by Congress on its $11-million bid.

. . . **Petrofina,** a Belgian oil firm who recently started refining operations in Canada (see p. 72, this issue), has taken its first step in establishing integrated operation in the U. S. It announced in late January plans to purchase a major stock interest in Panhandle Oil Corp.

Panhandle has an 8000 b/d refinery at Wichita Falls, Texas, about 3500 b/d of production on 3500 acres in Texas (plus about 250,000 undeveloped acres) and distributes products in north Texas., southern Oklahoma, and eastern New Mexico.

. . . **Lincoln Oil, Gas & Refining Co.** has been organized for nationwide exploration, producing, and refining operations. With producing properties in the Rocky Mountains, Oklahoma, Kentucky, and Illinois, the firm has a 50% interest in Seminole Asphalt Refinery Ltd., St. Marks, Fla., with a capacity of 2500 b/d.

. . . **Gaseteria, Inc.,** mid-west marketing firm, plans to purchase Johnson Oil Refining Co., including a 6500 b/d refinery at Cleveland, Okla. Gaseteria has not decided what use will be made of the refinery.



NEW T.C.C. UNIT JOINS 10 YEAR OLD SISTER AT EAST ST. LOUIS REFINERY

Two Thermofor Catalytic Cracking Units stand here side by side at Socony Mobil Oil Company's East St. Louis refinery, where for 10 years one stood alone. Both were engineered and constructed by The Lummus Company.

The first unit, with 10,000 B/D total charge and bucket lift for catalyst, went on stream in 1944 and has operated satisfactorily ever since.

The second unit, complete with feed preparation, fractionation, and gas recovery sections and using gas lift for catalyst circulation, went on stream in November 1954. Its total charge is 15,000 B/D.

We feel that the confidence which Socony showed in choosing Lummus for the repeat unit, and the installation of other East St. Louis facilities at the same time, was justified by our performance on the job.

Working closely with Socony engineers at the refinery and in their main office in New York, Lummus performed all work with a minimum of interruption to normal refinery operations – thus maintaining maximum possible refinery production.

The construction proceeded smoothly without interruption, and start-ups of the separate units were in line with a pre-established schedule, dovetailing them with periodic refinery maintenance shutdowns.

Perhaps this suggests some ways in which Lummus might serve you when you consider new or expanded facilities.

The Lummus Company, 385 Madison Avenue, New York 17, New York. *Engineering and Sales Offices:* New York, Houston, Montreal, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Caracas. *Heat Exchanger Plant:* Honesdale, Pa. *Fabricated Piping Plant:* East Chicago, Ind.

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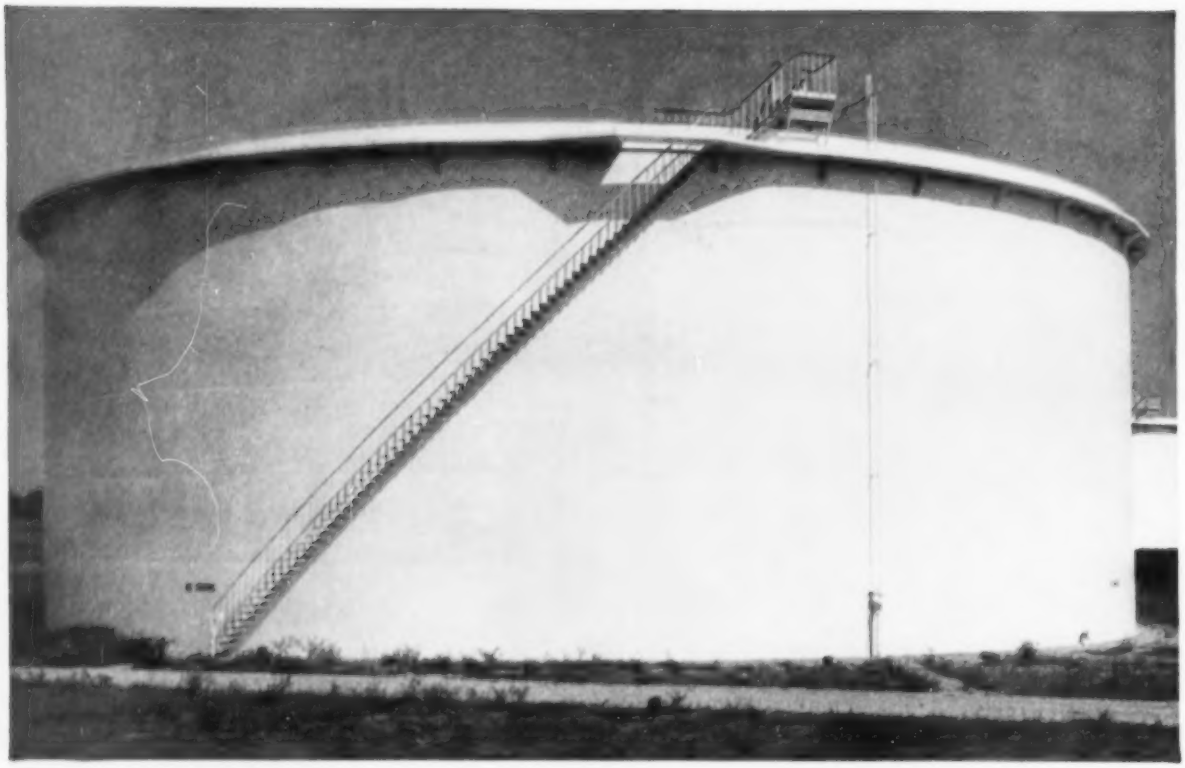
DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES



the GRAVER *"Double-Deck"—our costliest... and often least expensive... floating roof design*

While the Graver Double-Deck Floating Roof Tank is the costliest of our three "floaters," it often proves least expensive in the long run.

Its unusual strength and structural stability make it appropriate wherever storage problems are encountered. The double-deck roof, consisting of top and bottom deck plate, is divided into liquid-tight compartments. Thus it is practically unsinkable. With the Graver Double-Deck Floating Roof Tank maintenance costs are held to a minimum.

Other popular Graver designs include the Center-Weighted Floating Roof Tank which is unusually stable. We offer also a pan-type floating roof...an economical design suitable to southern climates where snow and ice present no hazard.

Whatever your storage needs it will pay you to contact Graver. Consultation costs you nothing, and competent Conservation Engineers are ready to serve you.

GRAVER *...a conservation design to fit every need*

GRAVER FLOATING ROOF TANKS, four of which were built for the TEXAS PIPE LINE COMPANY at Port Arthur, Texas.

GRAVER TANK & MFG. CO., INC.

East Chicago, Indiana

CHICAGO • NEW YORK • PHILADELPHIA • EDGE MOOR, DEL. PITTSBURGH • CLEVELAND • DETROIT • TULSA • SAND SPRINGS, OKLA. • HOUSTON • CASPER, WYO. • LOS ANGELES • FONTANA, CAL. • SAN FRANCISCO

(To obtain more data on advertised products see page 182)

Economic, Technical Road Blocks Could Delay Gas Turbine Cars

RECOGNITION of fundamental problems which must be solved before gas turbine-powered automobiles appear in any large number on the highways has dampened earlier enthusiasm somewhat.

Only about 18 months ago it was learned experimental cars with turbine engines were on the proving grounds of two car manufacturers (General Motors and Chrysler). It then looked like a short jump in years to the time such cars would be coming off the assembly lines. Now still a third company (Ford) has an experimental gas turbine vehicle.

In the meantime, however, cold appraisal of some of the realities involved in turning to a new type of power plant has deferred the date when it is believed gas turbine vehicles will be commercially produced. Hotel lobby discussions at the meeting of the Society of Automotive Engineers in Detroit in January put the date around 1965. Gas turbine vehicles also will be supplemental to piston engine and Diesel-powered cars and trucks. They will not supplant them.

One authority believes that, with the development of express highways across the country, the first application of automotive gas turbines will be in intercity trucks and buses.[1] Operating conditions on such roads will allow the gas turbine to be highly competitive with other prime movers. "When it is possible for a truck to leave New York and go to Chicago without stopping if necessary, the vehicle can operate at full power all the way," this report states. "Under these conditions the gas turbine operates at its best fuel consumption."

Some people close to the car manufacturing and selling field think a gas turbine-powered car may be offered to the public within five years. However, it will be a sports model in limited production and will be introduced through the pressure of the sales departments for a promotional "shot in the arm" to stimulate car sales generally. The automotive engineering and production departments, however, will not be happy if they are called on to design and manufacture gas turbine-powered vehicles before some of the presently known economic and technical problems are solved.

Among questions confronting designers are these:

1—What petroleum fuels for automotive gas turbines can be supplied by the oil companies in the required volume and availability? At present, turbine fuel consumption at low speeds, typical of most passenger car operation, is twice that of the gasoline engine. Although performance will be improved, the turbine will likely always be more of a fuel eater than the gasoline engine. It is felt the fuel trend should be toward a kerosine or distillate type which has more Btu. than gasoline and is basically available at a lower cost.

2—Is it sound planning to bring out an automotive engine which will develop more horsepower than the gasoline engine, when highway traffic conditions in this country are such that some groups advocate taxes and other limitations on engine horsepower?

3—Is it good engineering to turn to a new type of prime mover until the possibilities in further improvements in piston type engines are exhausted, such as fuel injection and free piston engines?

4—What effect will the exhaust from gas turbines burning a kerosine or distillate type fuel have on asphalt surfaced highways? This problem already exists at airports where gas turbine-powered aircraft use the runways.

5—Present day construction materials capable of withstanding the high temperatures of gas turbine operation are costly and in some instances their supply is not plentiful. New developments in materials and the methods of fabricating gas turbine parts will have to be found before volume production of turbines can be undertaken.

6—While the gas turbine is essentially a simple form of prime mover, will it remain so when the refinements and accessories are added which are essential for automotive use? These will include a heat regenerator, device for reducing engine noise, means for taking care of the large volume of exhaust as compared with a gasoline engine.

7—What type of lubricants can be supplied for gas turbines? In principle, lubrication needs are simple, a thrust bearing, main shaft bearing, and bearings for landing gears and other accessories. Volume used will be small compared with a gasoline engine, since no engine oil is required. Temperatures, however, are far higher than encountered in gasoline engines.

—V.B.G.

(1) "The Next Decade and the Automobile"; E. T. Vincent, F. L. Schwartz, Charles Lipson, A. K. Lahti, Charles Harris, University of Michigan, Ann Arbor, U. O. Lahti, Consultants to Management, Inc.; before Annual Meeting, Society of Automotive Engineers, Detroit, Jan. 9-13, 1956.

Gamma Ray "Catalysis" Promising For Hydrocarbon Chlorination

THE use of gamma rays to induce or speed various chemical reactions has recently been given a new boost. University of Michigan researchers estimate that the use of gamma radiation for benzene chlorination might cut the cost of benzene hexachloride in half. In addition, they have found that a wide range of aromatics —including toluene, xylene and mesitylene—are highly reactive starting materials for gamma ray induced chlorination.

Sponsored by the Atomic Energy Commission, the Michigan team used cobalt-60 as a radiation source, since development programs for packaging and shipping fission products have not as yet been completed.

In the manufacture of the gamma isomer of benzene hexachloride (lindane), production costs are estimated

to be 0.69/lb. versus $0.86-1.36/lb. by the present ultraviolet method. However, since the costs of the fission products assumed for the process are still conjectural, this cost is not firm.

An outstanding advantage of gamma rays over ultraviolet light for inducing chlorination reactions, is that the gamma rays can penetrate the whole mass of the reaction mixture, and do this through a metal reaction chamber. Ultraviolet light affects only the outside surface layer of the reaction mixture, and reactors must have a "window" transparent to the rays.

Toluene can be chlorinated at low temperatures (20°C). Both addition to the ring and substitution in the side chain occur. But the products obtained by gamma radiation differ markedly from those obtained by ultraviolet activation plus heat.

Speed of gamma ray induced reactions can be a mixed blessing. Problems include temperature control and the reactor plugging with solid product during the benzene chlorination. For this reason, most of the Michigan experiments required its dilution with carbon tetrachloride.

Don't however, assume that chlorinating benzene in the presence of ultraviolet light is obsolete. Manufacturers cite the fact that Stauffer Chemical Co. is pilot-planting a process that's said to double conventional yields. Also, lindane's market future may not merit a crash program to replace existing facilities.

With the host of materials susceptible to gamma ray induced chlorination, gamma rays should soon graduate from the lab to the plant. —R.L.D.

Anon., *Chemical Week*, Jan. 28, 1956, pp. 54, 56.

Automation to Bring Big Changes in Industrial Management Concepts

AUTOMATION will bring some drastic changes to our usual concepts of how business is done, according to Dr. Elmer W. Engstrom, senior executive vice-president of the Radio Corp. of America.[1] What's more, it means new functions and qualifications all through the occupational structure.

The key to the proper use of automation is in directing it toward an integrated business, Dr. Engstrom believes. "Automation must not be directed just toward production. . . . It is a system, a method, a working arrangement of the whole business."

But this key must turn in a complicated and unyielding economic lock. For, as automation progresses, fewer and fewer workers will be directly engaged in production. Instead, "We will have many persons employed to design, to build, to service, to control, and to make decisions. This will call for greater skills and for more training and education. It will mean a general upgrading of personnel." Management's investment in each employee will thereby increase—in some cases by tens or hundreds of times.

The economic compulsion to use this enormous investment efficiently will lead to continuous production. And this means a less flexible adjustment to market conditions. In fact, Dr. Engstrom says, "Marketing and sales will in the future have to be adjusted to a constant or at least slowly changing flow of goods and services, instead of production being adjusted to sales, as is largely the case . . . today."

People in the petroleum refining and chemical industries won't feel these are such big changes. They did much to invent and develop automation and are familiar with its problems. But can't refiners look for a "feedback" here? If they are alert they may find answers to their technical and organizational problems filtering back to them as other industries come to grips with the new concepts of the automatic era. —S.D.B.

(1) "Automation," delivered at the Centennial Symposium on Modern Engineering, University of Pennsylvania, Nov. 11, 1955.

Send Pictures by Wire or Radio—Next in Faster Communication?

WHO hasn't at some time had trouble with communications, either at home or work? It's often tough to get your viewpoint over to some one else without misunderstanding. And it is well appreciated that most arguments result from misunderstanding.

In refinery or petroleum operations, plants are growing larger and control centers moving further away from actual operations. As a result, the problem of conveying information is bound to increase. Even when this is left to instruments there is always the human reluctance to believe until the information is actually seen.

Typical of the problem of communicating ideas is the dependence on a pad-and-pencil by many individuals in getting across their ideas.

Looking into the future—and the not-too-distant future at that—one has the feeling that as the mechanics of living continue to grow complex it is going to be more difficult than ever to communicate with others, especially over long distances. But two recent announcements indicate that we may all get some help—even the fellow who needs a pencil and pad—from new communication machines.

One method is a remotely-operated TV system for in-plant use, including a multi-lens TV camera and separate control console which automatically operates the camera as though a cameraman were behind it.

Designed especially for hazardous locations, it permits observation of otherwise unwatchable reactions equipment testing too hazardous for personal observation, and for undetected security surveillance.

Another new instrument designed for tomorrow's communications is the long distance transmission of pictorial material, via voice microwave radio. Maps, drawings, photographs or operating charts can be relayed over long distance, even up to 1,000 miles.

As one more step in the direction toward automatic control, graphic communications promises to centralize controls. Far-flung operations in large integrated companies or pipeline systems now have two more tools that can reduce misunderstandings by more graphic communications. —W.A.B.

For Optimum Efficiency at Minimum Cost, Heat Transfer Equipment Needs Kellogg's

BUILT-IN ENGINEER

WHEN a process plant's efficiency, and even its economic success, depends on the performance of heat exchangers, this vital equipment becomes more than a "packaged" item or even a matter of following specifications. Optimum performance, at minimum cost to the customer, demands all of the extra know-how, know-when, and know-where that the fabricator can put into the job. It requires, for example, a thorough knowledge of heat transfer, stress analysis, metal fatigue, corrosion control, metallurgy, and welding techniques, plus the inherent ability to apply this knowledge to the specific problem at hand.

At M. W. Kellogg, the instinctive application of this kind of knowledge—which goes into the design and fabrication of every Kellogg heat exchanger or other processing unit, is what we call the "built-in engineer". This important extra, together with Kellogg's other facilities guarantees performance, minimizes maintenance, and often reduces initial costs. In one recent instance, a saving of $5,000 for a customer resulted from a slight change in design suggested by Kellogg's staff.

We welcome the opportunity to demonstrate, in cooperation with your own design engineers or alone, what Kellogg's "built-in engineer" can contribute to *your* new process equipment.

Fabricated Products Division

THE M. W. KELLOGG COMPANY, 225 BROADWAY, NEW YORK 7, N. Y.

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1943

"Progress."

1944

Safety-Relief Valves
Balanseal Bellows Valves
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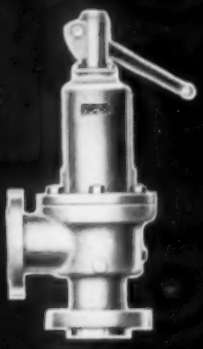
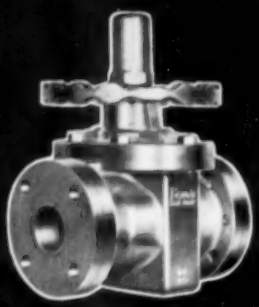
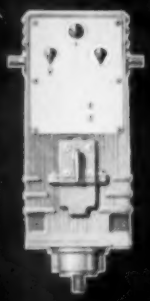


1945



Pinch Type Flexible
Diaphragm Disc and
SuperSeal Valves
Farris Flexible Valve Corp.

1951



Mechanical and
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U. S. Patents and Patents Pending

1955

. . through honest purpose"

The larger and more experienced a manufacturer becomes, the more he appreciates that PROGRESS is not restricted to simply producing fine products at fair prices. Rather, it is the sum total of all the services he renders to his customers day by day and year by year. It is unceasing vigilance to assure customer satisfaction . . . it is constant concern for improvement—for *better* products at even *better* prices . . . it is strict adherence to a commercial code of honor, like Farris' policy of "Progress—Through Honest Purpose".

Evidence of this policy's success is seen in the rapid and constant growth of the Farris organization. And even as you read this, more facilities are being added . . . designed to provide even greater service for users of Farris Safety and Relief Valves (which have set the pace in design and performance and have been duplicated by other manufacturers), Farris "SuperSeal" Flex Valves and Farris Pickering Governors.

Behind our continuing growth and the world-wide recognition of Farris as a pacesetter in its field, is the fundamental belief that "honesty of purpose" when dealing with people is always to be trusted. Upon this belief we have grown . . . and, because they believe in the same things, our customers and friends have supported us. Here, beyond doubt, is proof that the right way to grow is THROUGH HONEST PURPOSE.

and HOUSTON, TEXAS 1955

PROGRESS THROUGH Farris HONEST PURPOSE

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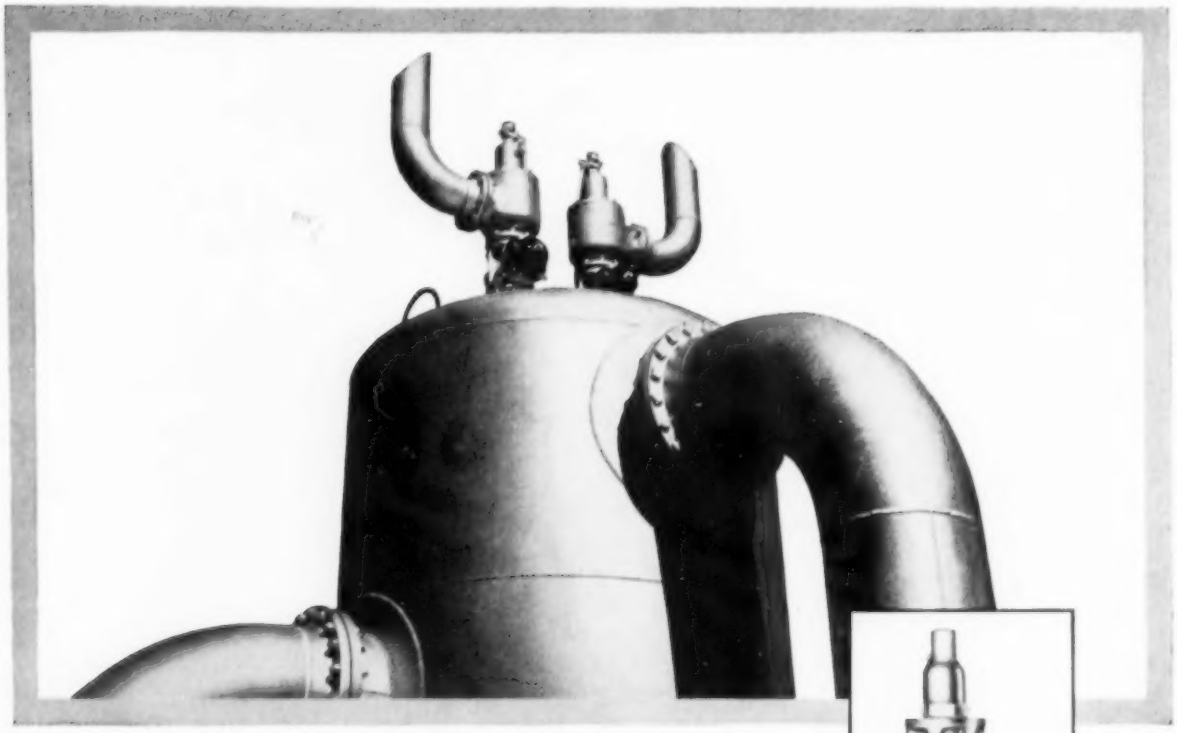
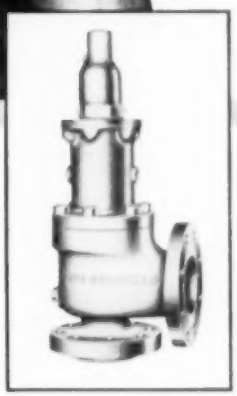
- Farris Flexible Valve Corp.
- Farris Pickering Governor Co., Inc.
- Farris Hydrotorque Corp.
- Farris Hydroseal Corp.





★ Economical "2 in 1" Design
★ Peak Performance
★ Absolute Protection
★ Maximum Interchangeability

CONSOLIDATED SAFETY RELIEF VALVES GIVE YOU ALL FOUR—AND MORE

Consolidated Safety Relief Valves satisfy *every* requirement of the most advanced processing facilities. Valve action is *consistently* positive. You get peak performance even where discharge lines are long or there is low "superimposed" back pressure in the relieving system!

The Standard type can be converted to Bellows type *in the field*. Center-to-face dimensions of inlet and outlet are such that you can interchange these valves with the safety relief valves of other manufacturers. Real flexibility of application that cuts inventory costs! Optically-ground flat seating surface and fewer functional parts than comparable valves contribute greatly to easier, more economical maintenance.

Get top economy and absolute protection with Consolidated Safety Relief Valves. Full range of sizes and pressures available. Write for Catalog 1900 for complete information.

CERTIFIED AND APPROVED. Both Standard and Bellows Valves are approved under API-ASME and ASME Unfired Pressure Vessel Codes and are certified by the National Board of Boiler and Pressure Vessel Inspectors.

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CONSOLIDATED SAFETY RELIEF VALVES

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MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

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PETROLEUM CHEMICALS DIVISION

NEWS

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March • One of a Series of Interest to the Petroleum Industry • 1956

Question Box

1. ARE YOU having trouble keeping costs down as octane ratings go up?
   The new Du Pont service described at right can help you with this problem.
2. DO FOULED heat exchangers plague you with costly downtime and spoiled product?
   Du Pont FOA-2 may help solve this problem.
3. IS THERE A DANGER of additive extraction when fuel oils pass through dehydrators?
   The next page has an article on this subject.
4. WHO can help you get the highest octane at the lowest refining cost?
   See next page.

FOA-2 reduces heat exchanger fouling—helps keep process unit on stream longer

Fouled heat exchangers cost time and money and premature process unit shutdowns.

Du Pont Fuel Oil Additive No. 2 (FOA-2) promises relief from this frequent and troublesome problem.

A little does a lot

Fouling due to unstable stocks such as coker distillates can be minimized by adding FOA-2 in concentrations of as little as 20 to 30 lbs. per 1,000 barrels. It should be added at the beginning of the processing run.

In cases where the heat exchanger fouling is severe enough to cause shutdowns as often as every few days, this treatment will generally extend, to as much as a month or two, the period between shutdowns. And during this extended operating time, FOA-2, as a result, will help to reduce the loss in heat transfer coefficient.

Useful in pipelines, too

Another effective application for FOA-2 is for cleaning pipelines. In concentrations of 50 lbs./1,000 barrels, in No. 2 distillate, it does an excellent job of keeping the contamination in suspension and removing it in advance of the new product.

Why not try it? Its rapid, thorough cleaning will mean lines that are free of contamination and ready for clean product service immediately.

Other uses

Du Pont Fuel Oil Additive No. 2 was originally developed as a stabilizer and dispersant for home heating oils. As such, it does a highly efficient job of preventing and dispersing sludge formations that cause screen and filter clogging.

In addition—being a nonmetallic *ashless* additive—it does not leave a metallic ash deposit which can foul the operation of the electrical system. Thus, it helps to prevent ignition failures that cause customer dissatisfaction and wasteful service calls.

In diesel fuels, the excellent dispersant action of FOA-2 improves filterability. In this way, it helps to eliminate most injector-sticking and filter-plugging problems.

THIS DU PONT TECHNICAL SERVICE MEANS . . .

More octane numbers per dollar

Octane requirements are increasing so fast that many refiners are facing the choice of either a squeeze on their profits or an advance in their gasoline price. This predicament is brought about by the pyramiding costs of each octane number increase in the 90 to 100 range. In this connection, there are times when a refinery technologist experienced in this specialized field may be of considerable help in the control of costs.

Jack S. Bellah, a Du Pont refinery technologist, is shown here discussing a more economical method of obtaining octane numbers.

The Du Pont Petroleum Chemicals Division is glad to offer you the services of such specialists. The value of their services has been proven in a number of refineries during the past year.

Based on market requirements

Unfortunately, most refiners are forced to do a certain amount of uneconomical processing in order to balance their particular market requirements. But this does not mean that substantial savings in processing cannot be realized—by carefully analyzing and adjusting *all* the factors influencing octane costs.

These factors include the particular gasoline blend, the octane level under consideration, and

OVER

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PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED *Octane Economy*

the method of achieving this desired level. These factors, and their relation to each other, will vary with each individual refining operation. Also affecting the octane cost are the spread in value between intermediate fuels immediately adjacent to the gasoline fraction, and the flexibility of the market between these fuels and gasolines.

Tailored to your operations

For these reasons, the Du Pont *octane economy service* also takes into consideration all the market factors which influence your refining operations. Then a thorough study of the actual processing operations is made to determine the most economical course for reaching your desired octane requirements.

How it's done

Assuming that catalytic reforming is today the principal processing variable in gasoline quality control, then the method of operating the reformer determines to a large extent the cost of achieving a desired octane level.

For maximum economy

At all octane levels, the most economical cost results when the optimum combination of catalytic reforming operations and tetraethyl lead dosages is used. In some instances the maximum usage of TEL, 3.0 cc per gallon might be more economical than increasing the severity of the reforming operation. But this is by no means always true. Generally a combination of moderately severe reforming conditions, commensurate with the octane requirements of the existing market situation, and intermediate TEL dosages result in the lowest possible costs.

Valuable aid

By determining the most economical processing steps and reforming severity, in relation to your own individual stocks and market requirements, the Du Pont *octane economy service* can provide a most valuable aid to your own process engineering.

If you would like more information about this service and how it can help you maintain your profit margins, just drop us a line.

HEADS DU PONT OCTANE ECONOMY SERVICE

Jack S. Bellah joined the Petroleum Chemicals Division as Refinery Technologist in 1953. A graduate of the University of Tennessee with a B.S. degree in chemical engineering, he completed a year of study under a T.V.A. chemical engineering scholarship.

For six years, he was employed by the Socony-Vacuum Oil Company. His activities ranged from routine control testing through heavy oils blending, conservation engineering, operations control and equipment testing, unit yields and economic studies, process engineering and product development.

He then joined Mathieson Alkali where he was engaged in chemical engineering development work.

In 1946, he became a process-project engineer at Stanolind Oil and Gas Company in Tulsa. After working on two of the large joint venture gasoline plant projects in West Texas, he joined the Refinery Engineering Company in Tulsa in 1950. There he coordinated all the company's process activities and economic studies.

Do dehydrators remove Du Pont FOA-2 from distillate fuels?

Laboratory and field tests prove the absorption rate is *less than 1%*. And the negligible amount absorbed does not interfere with the water removal efficiency of the bauxite dehydrators.

For example

In a field test, 74,000 barrels of a No. 2 distillate fuel oil were treated with 18.8 pounds of Du Pont Fuel Oil Additive No. 2 per 1,000 barrels. This stabilizer and dispersant was injected into the circulating line of the storage tank while the fuel was being recirculated. The storage tank contained 8 inches of water. Since the fuel was destined for shipment through a pipeline, a dry fuel was desired.

The treated fuel was pumped from the storage tank through two 100-barrel capacity bauxite dryers operating in parallel, then into the pipeline. Each dryer contained sixteen tons of bauxite.

The test fuel was sampled before and after the dryers . . . and at regular intervals throughout the 31-hour shipment.

Results

The fuel was bright and dry when it left the dehydrators. The FOA-2 content of fuel entering and leaving the dryers was equal. It remained uniform throughout shipment.

When the fuel was checked in at destination, no loss in stability was noted and in this respect the fuel proved to be superior to the base fuel without additive.

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A-989

Printed in U. S. A.

more and more refineries find new KEY type 5000 fitting right for their heaters...

These outstanding companies among many now served by newly developed refinery fitting...

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Introduced recently, this new Type 5000 Fitting by Key Co. has achieved almost overnight recognition and acceptance by the refinery industry.

Most prominent feature of the Key 5000 Type Return Bend Fitting is its simplicity. With two series available of nine fittings each, the 18 fittings contain only 26 parts instead of the conventional 72 in other fittings of this type.

This reduction in the number of parts—made possible by the fittings' high degree of interchangeability—permits substantial lowering of inventory and inventory cost.

Write today for detailed information and prices on this unique fitting. All parts, exclusive of the body casting, are available for immediate shipment from stock.

Key company

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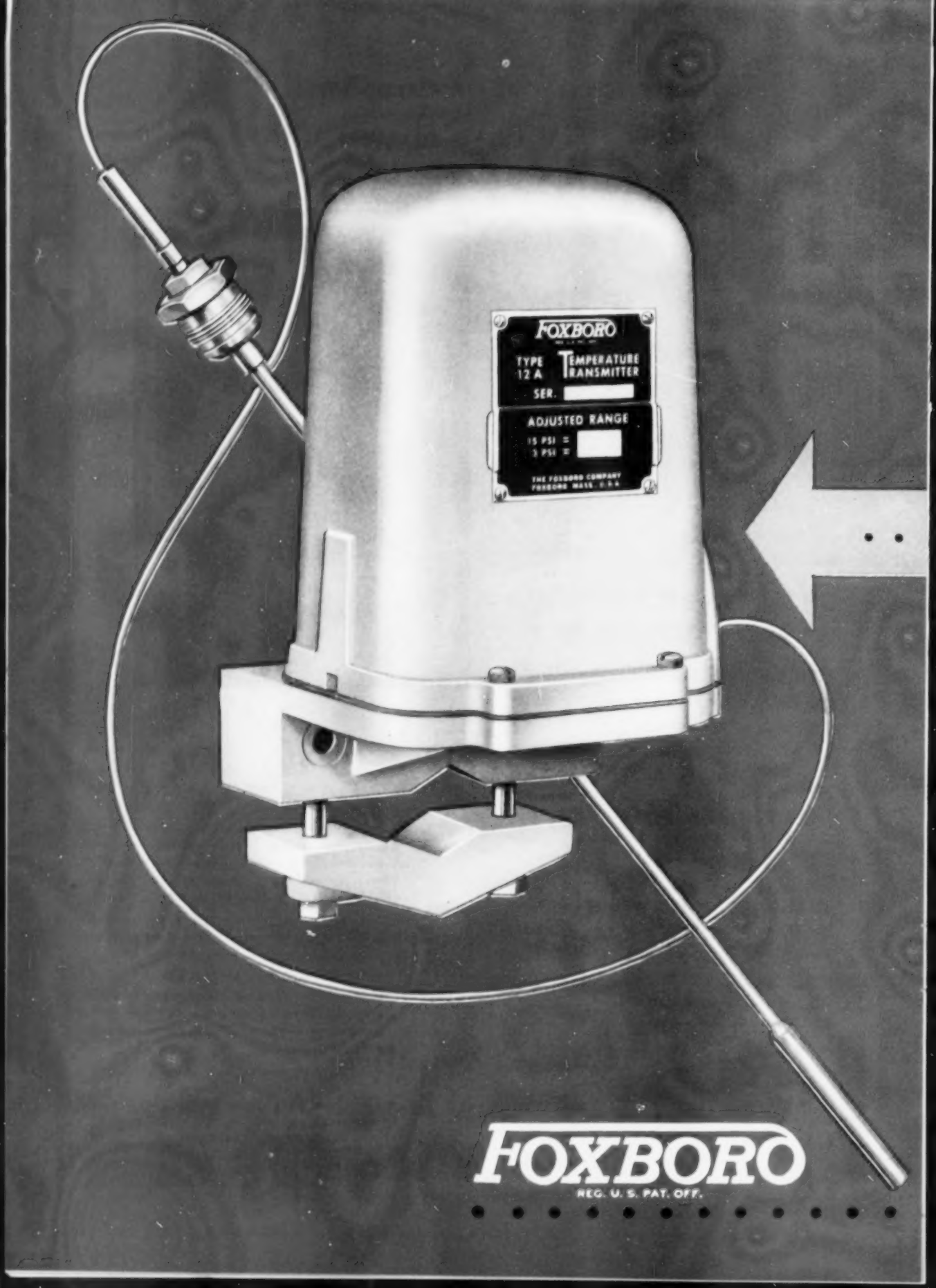
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There is no easier, simpler way to measure remote temperatures, *fast*, over so wide a range, with such high sustained accuracy, and at so low a cost!

Between the limits of —100°F. and +1000°F., with operational spans of 50°, 100°, 200°, and 400°F, this rugged, highly responsive instrument performs outstandingly under the most severe conditions. It is compensated for ambient temperatures and pressure. Derivative action can be furnished for optimum performance when substantial thermal or transmission lags exist.

With its weatherproof housing and integral mounting bracket, it can be installed in any hazardous, corrosive, or outdoor location. Transmission lines are standard copper tubing, no electrical hazard, no costly capillary to run.

Write for Bulletin 13-17. It explains fully why the Foxboro M/12A Temperature Transmitter gives better performance with lower installation and maintenance cost. **The Foxboro Company, 913 Neponset Ave., Foxboro, Mass., U.S.A.**

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The packed bag is not just a figure of speech at McKee. Our engineers are off at the drop of a hat for Calcutta or Caracas—or any other place in the world where iron and steel are made or where oil or chemicals are processed—wherever industry builds.

For half a century McKee has been designing and building plants on a world-wide scale for both American and foreign companies that want the best American know-how available. And whether they are two miles from our offices or ten thousand, all McKee-engineered projects get the same meticulous quality of design and construction that has characterized the work of this organization for fifty years. It's the kind of engineering that can create a profit-producing plant for you.

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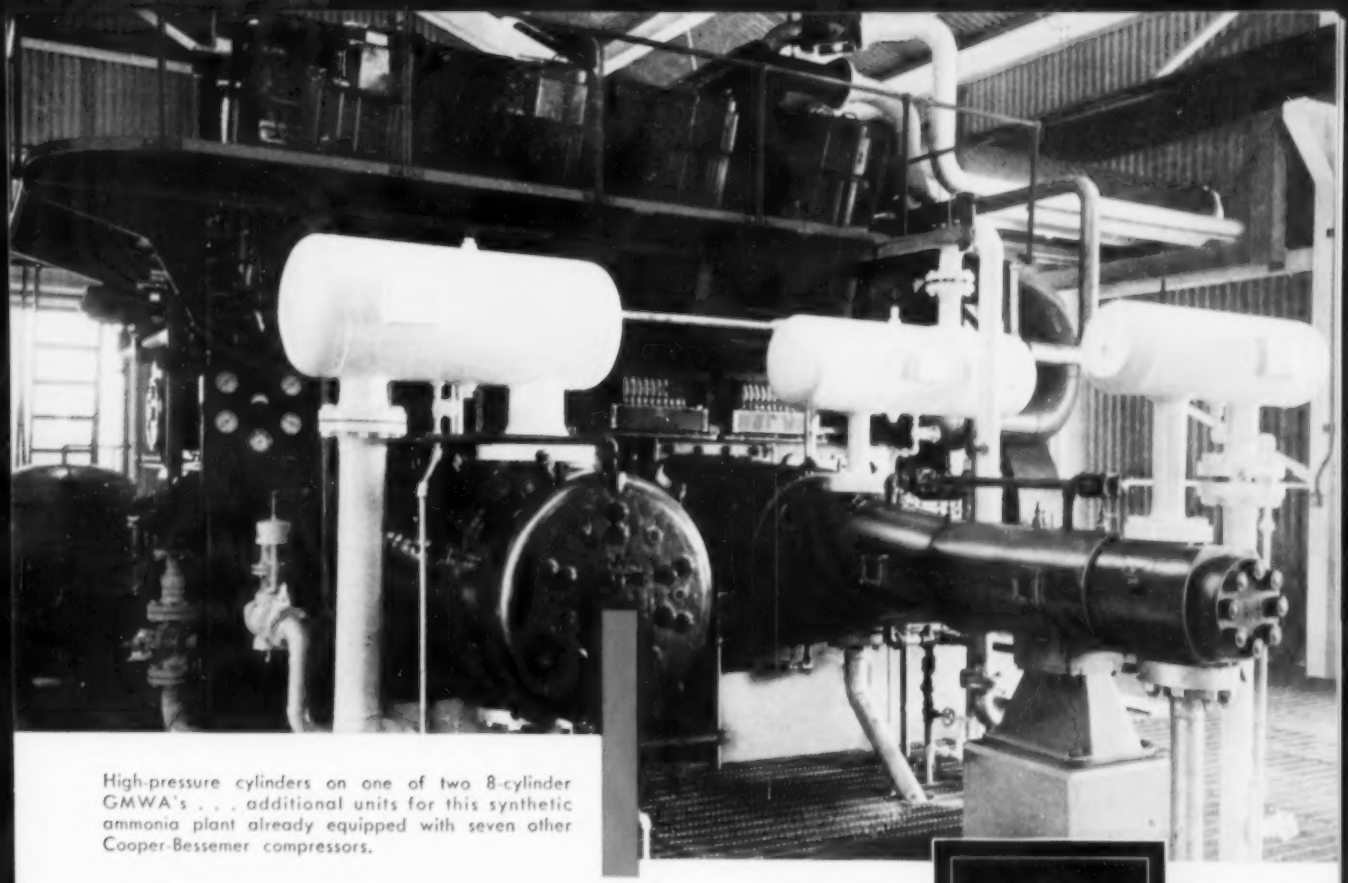

High-pressure cylinders on one of two 8-cylinder GMWA's . . . additional units for this synthetic ammonia plant already equipped with seven other Cooper-Bessemer compressors.

Another Example of Efficient Power at Lower Cost

Full-load operation . . . all the time!

with Cooper-Bessemers in high-pressure ammonia service

• When it comes to compressor horsepower, this Texas synthetic ammonia plant has an important advantage in common with scores of other plants throughout this country and abroad . . . they all benefit from the low maintenance, high operating efficiency of Cooper-Bessemer compressors.

The plant shown here, for example, recently added two 2000 hp Cooper-Bessemer GMWA's to meet increased work demands. This one plant now boasts more than 10,000 Cooper-Bessemer horsepower to effectively handle recirculation and the processing of a hydrogen-nitrogen mixture, through five stages, from 2.5 to 5300 psig.

Since Cooper-Bessemers are especially designed to easily handle the most severe work demands, full-time at full-load operation presents no handicap to the smooth service delivered by these work-wise units.

Whether your requirements include heavy-duty compressors for chemical, petrochemical or virtually any other type service, you'll profit by contacting the nearest Cooper-Bessemer office. Let one of our experienced sales-engineers tell you about the latest developments now being offered by one of America's oldest engine and compressor builders . . . Cooper-Bessemer.

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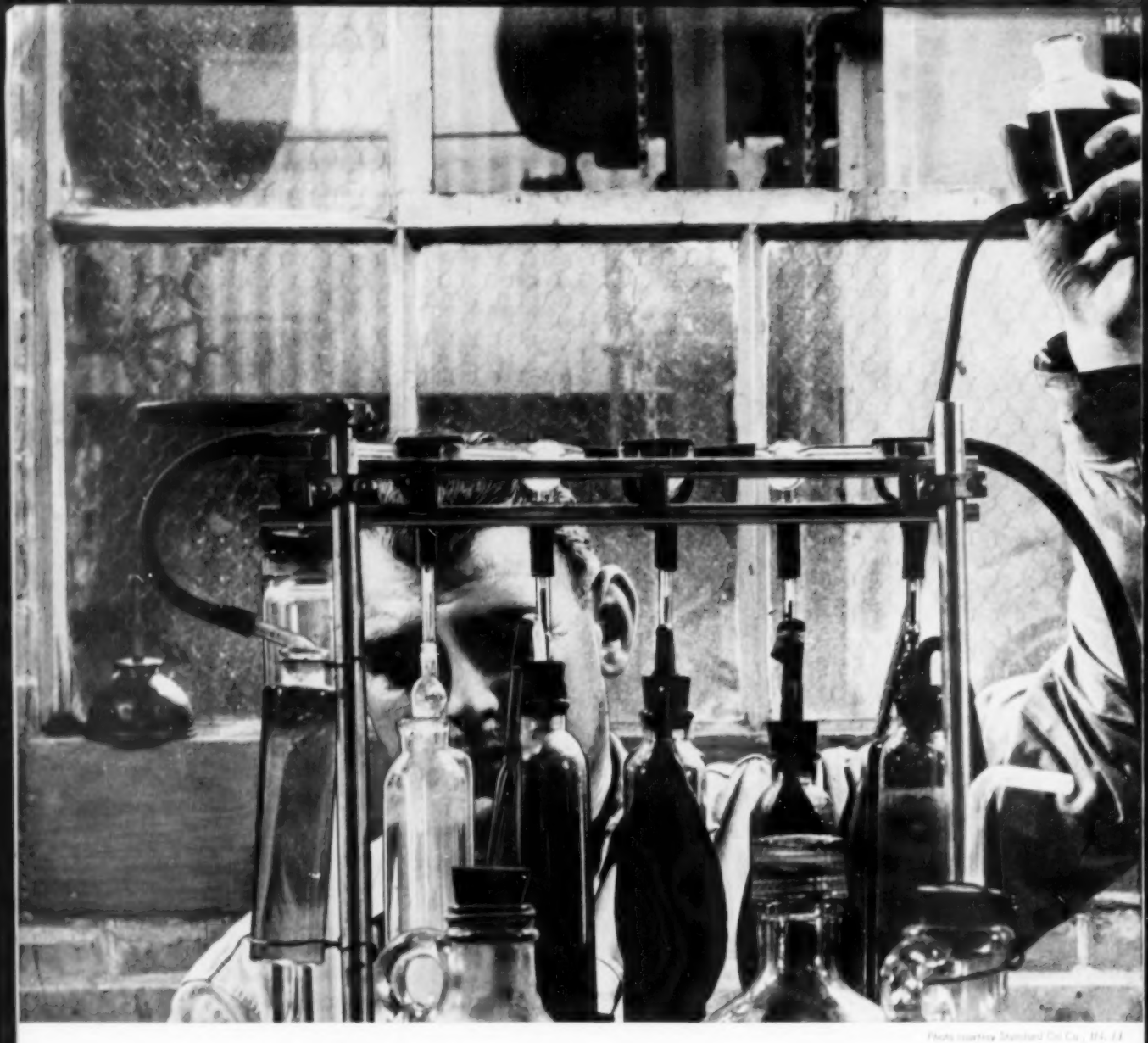

Photo courtesy Standard Oil Co., N.J.

boost average ratings as much as 2 octane numbers

with the LJUNGSTROM® AIR PREHEATER

With waste heat recovered and returned to the furnace in combustion air, the most modern heat-transfer systems can be operated at peak efficiency.

That's why you boost product quality with the Ljungstrom Air Preheater. Its heat-recovery efficiency makes possible advanced furnace designs that assure remarkably close control of processing. And finer control means a more uniform product . . . with average ratings as much as 2 octane numbers higher. One still's added income just from higher product quality is $58,000 annually.

How fast is "WRITE-OFF"?

In earnings from higher octane ratings, many refiners write off the cost of the Ljungstrom installation in less than two years. This time is cut to nine months and even less, when the other Ljungstrom advantages are taken into account — saves up to 20% in fuel costs . . . permits more economical furnace design, with no need for convection surfaces . . . burns many fuels you used to throw away . . . results in consistently higher through-put . . . and minimizes slag.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits obtainable in fuel burning equipment — call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljundstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

Zallea-designed Expansion Joints assure positive protection from damage caused by pipe movement. The units shown here—gimbal, hinged, and universal types—absorb pipe movements in any direction, imposing minimum forces on adjacent piping, equipment and anchors. An original Zallea development, gimbal expansion joints permit angular movement in any plane, with gimbal ring and hinges built to withstand pressure thrust and to support piping.

Zallea already has, or will design, expansion joints for every service—and to suit any piping layout. Test records show that Zallea Expansion Joints outlast all other packless joints by as much as 1800%. For information on standard types, or consultation on special expansion or piping problems, ask to have a Zallea representative call.

Zallea *expansion joints*

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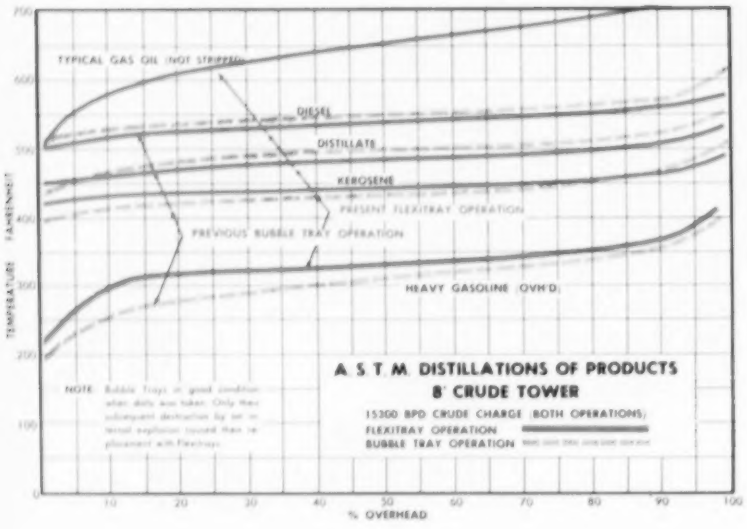
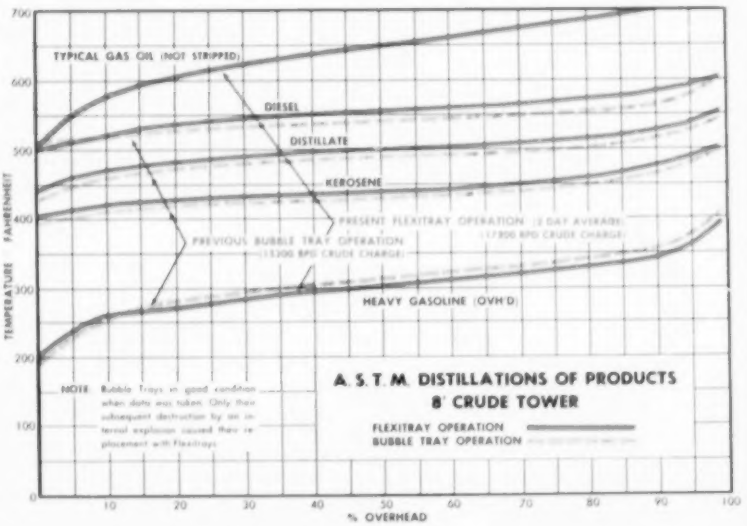
Why Top Performers Prefer

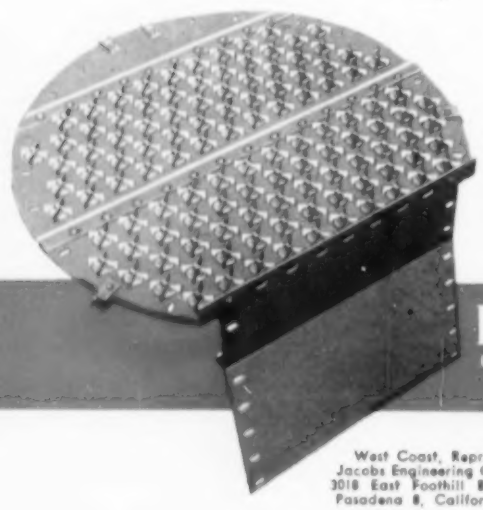
KOCH Flexitrays FOR CRUDE PETROLEUM DISTILLATION


TYPICAL GAS OIL (NOT STRIPPED)
DIESEL
DISTILLATE
KEROSENE
PRESENT FLEXITRAY OPERATION
PREVIOUS BUBBLE TRAY OPERATION
HEAVY GASOLINE (OVH'D)
TEMPERATURE FAHRENHEIT
% OVERHEAD
A. S. T. M. DISTILLATIONS OF PRODUCTS
8' CRUDE TOWER
15300 BPD CRUDE CHARGE (BOTH OPERATIONS)
FLEXITRAY OPERATION
BUBBLE TRAY OPERATION
NOTE: Bubble Trays in good condition when data was taken. Only their subsequent destruction by an internal explosion caused their replacement with Flexitrays.

The superior efficiency of the Flexitray at maximum bubble tray capacity is illustrated in the adjacent graph. The bubble tray ASTM's are indicating deterioration of quality and yield due to the presence of "End Point Tails." No such loss of efficiency is indicated by the Flexitray operating under identical process and thruput conditions. ←

The adjacent graph illustrates results with Flexitrays operating at some 11% above the "practical" capacity of bubble trays. Note that at this higher thruput the Flexitray is producing products of comparable quality to that of the bubble tray at a lower rate of thruput. The performance records of the Koch Flexitray are outstanding. Wire, write, or phone us on its application to your problem. →


TYPICAL GAS OIL (NOT STRIPPED)
DIESEL
DISTILLATE
KEROSENE
PRESENT FLEXITRAY OPERATION (2 DAY AVERAGE)
(17800 BPD CRUDE CHARGE)
PREVIOUS BUBBLE TRAY OPERATION
(15300 BPD CRUDE CHARGE)
HEAVY GASOLINE (OVH'D)
TEMPERATURE FAHRENHEIT
% OVERHEAD
A. S. T. M. DISTILLATIONS OF PRODUCTS
8' CRUDE TOWER
FLEXITRAY OPERATION
BUBBLE TRAY OPERATION
NOTE: Bubble Trays in good condition when data was taken. Only their subsequent destruction by an internal explosion caused their replacement with Flexitrays.



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Ed— This is something for every oilman to think about!
G.H.

PUBLISHER'S PAGE

Whose Job Is It?

Whose job is it to see that the oil business has a better understanding at the hands of the public? Is it just the job of the American Petroleum Institute and its committees? Is it just the job of the company executive who may be a heavy stockholder—or who may not be but who has an interest in keeping a good job?

No, the responsibility goes far deeper than that. It goes to *every* individual who works in the oil business whether he works out in the oil fields, in a refinery, on a pipe line or works at a pump in a filling station.

If he intends to stay in the oil business then he had better do everything he can to help the oil industry get and maintain a good name at the hands of the public. His job is likely to be just about as stable as is the reputation of his industry

How can you or anyone employed in the oil industry help it to secure and maintain a good name?

The answer to that is easy:

• So conduct yourself in all of your operations as an oil man in contact with the public so that the public will feel "that's a good oil company to do business with."

• If you hear somebody making a statement about the oil industry which your own information tells you is untrue, correct it in a friendly manner.

It is just as simple as that. If the several million employes of the oil industry in the U. S. will do just these two things, the results will be far greater than could be expected from a multi-million dollar advertising campaign.

And just as an editorial writer in one of our publications said last month, "this is not a job for just a week in the year —it is an every-day job, 365 (leap year 366) days in the year."

Ray L. Dudley

Current Outlook Section - 43

This editorial, of vital importance to all oil men and women, appeared in the January, 1956 issue of WORLD OIL and is presented for your information by the

AMERICAN PETROLEUM INSTITUTE
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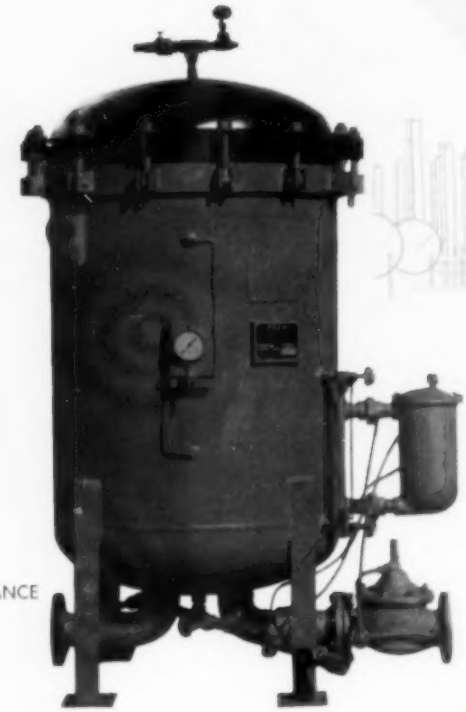
FRAM-WARNER LEWIS

NEW VERTICAL SEPARATOR / FILTER



FOR WATER AND SOLIDS REMOVAL FROM LIQUID FUELS

- OPERATES ON LIQUID FUELS (JP-3, JP-4, JP-5, AVIATION GASOLINE, KEROSENE, DIESEL FUEL, NO. 2 FUEL OIL, SOLVENTS, AROMATICS, ETC.)
- REVOLUTIONARY FEATURES TO SIMPLIFY MAINTENANCE (SWING BOLT COVER WITH MECHANICAL LIFTING JACK, SCREW BASE CARTRIDGES)
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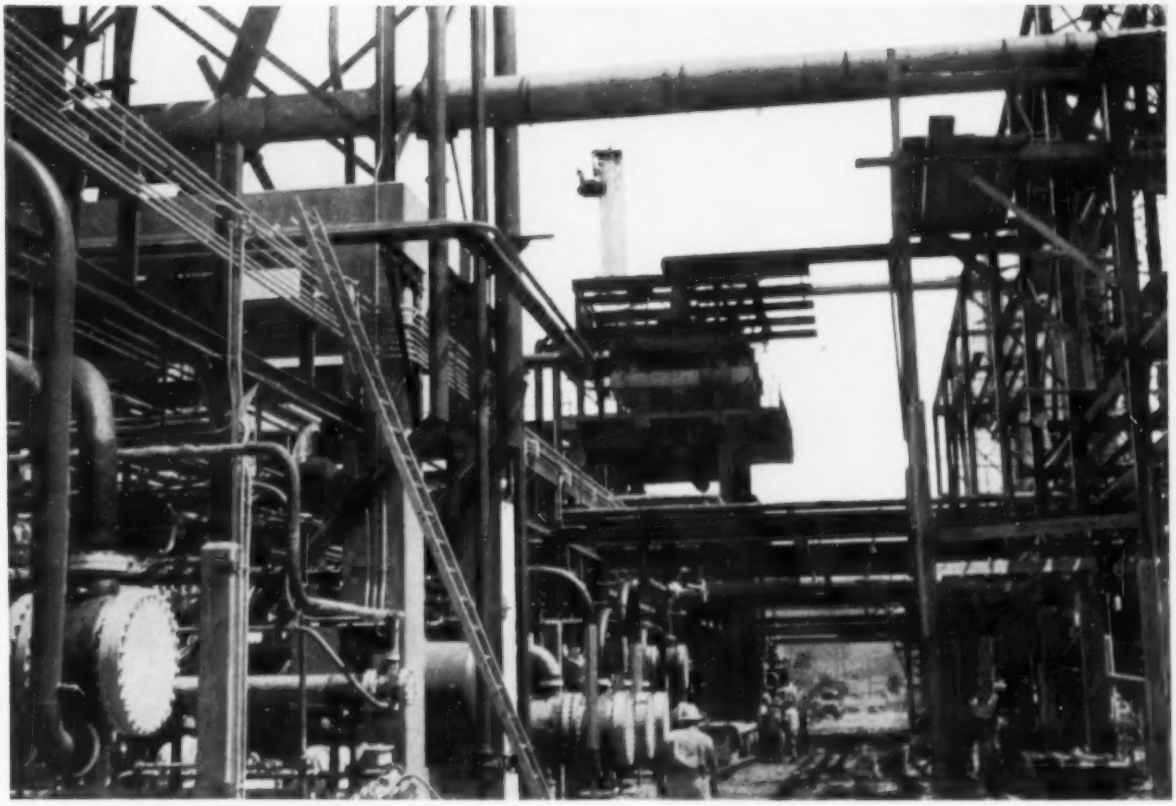

Over 200,000 Sq. Ft. of Tube Surface for Commonwealth at Ponce, P. R.

In 1955 Lummus designed and built all of the heat exchangers for Commonwealth Refining Company's complete new refinery at Ponce, Puerto Rico. Well over 100,000 sq. ft. of tube surface is represented in exchangers for the atmospheric and vacuum distillation unit, Houdriflow fractionation and vapor recovery sections, Houdriformer, sulfuric acid alkylation and acid regenerating units, and catalytic polymerization unit.

Before the original refinery was placed in operation, Lummus was requested to increase the refining capacity by approximately 150%. The new addition is scheduled for completion by the end of 1956. Repeat orders on Lummus designed equipment are frequent, because Lummus heat exchangers are engineered to meet customer requirements for long and trouble-free service.

The Lummus Company has now established a standard line of heat exchange equipment to meet the requirements of TEMA Class "R" and API-ASME code requirements. Write for your free copy of Bulletin MD-164 which completely describes this equipment.

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LUMMUS
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IN PETROLEUM (*Gasoline Additives, Lubricants*)

IN CHEMICALS (*Synthetic Fabrics and Yarns*)

Enjay assures you satisfied customers

To satisfy your customers with high quality, dependable products, specify Enjay chemicals. The Enjay Company supplies a diversified line of uniform, high quality petroleum chemicals to the surface coating, chemical and petroleum industries. Through the facilities of the *new Enjay Laboratories* you can be assured of the best application of Enjay products in your chemical needs.

PETROLEUM	SURFACE COATING	CHEMICAL
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PARATONE	PETROMOL 95	PETROMOL 95
PARAFLOW	PETROMOL 99	PETROMOL 99
PARAPOID	JAYSOL	JAYSOL
PARADYNE	Secondary Butyl Alcohol	Iso-Octyl Alcohol
PARATAC	Secondary Butyl Acetate	Decyl Alcohol
PETROMOL	Isopropyl Acetate	Denatured Ethyl Alcohol
Methyl Ethyl Ketone	Acetone	Tridecyl Alcohol
Dewaxing Aid	Methyl Ethyl Ketone	Dicyclopentadiene
Ethyl Ether	Dicyclopentadiene	Isoprene
Isopropyl Ether	Ethyl Ether	Butadiene
Reference Fuels	Isopropyl Ether	Ethyl Ether
RUBBER	Naphthenic Acids	Isopropyl Ether
ENJAY BUTYL	Iso-Octyl Alcohol	Tetrapropylene
VISTANEX	Decyl Alcohol	Trigropylene
	Denatured Ethyl Alcohol	Aromatic Tars
		Benzene
		Acetone
		Methyl Ethyl Ketone

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If you own securities . . . if you're paid a salary . . . if you earn commissions . . . no matter how you make your income, the starting point is brick. Refractory brick.

Refractories, the industry behind industry. Refractories that contain and control flame . . . the flame that produces metals, glass, paper, rubber, oil, cement, power, transportation. Everything that's made or moved requires them.

But those requirements vary . . . vary over a vast range of applications. To provide them in almost infinite variety and enormous quantity, Grefco employs extensive research, maintains the world's most modern refractories laboratory, and supplies a Complete Refractories Service from strategically located plants, both here and abroad, that draw on the world for materials.

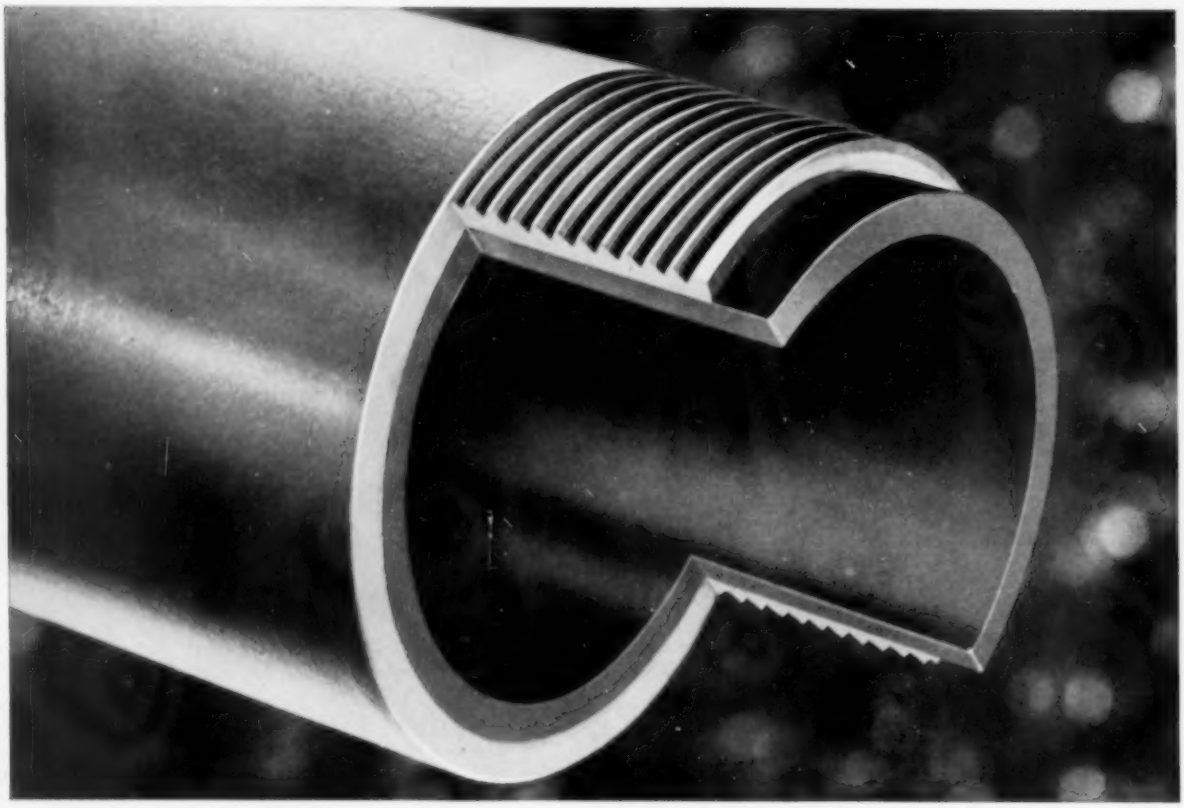
A Complete Refractories Service
GENERAL REFRACTORIES COMPANY
Philadelphia 2

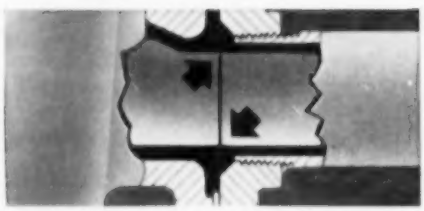
SEND FOR THE MOTION PICTURE: THE GREFCO STORY

It is a beautiful 16 mm. motion picture in full color and sound which relates the fascinating and little understood story about the refractories industry... *the industry behind industry.* Viewing time is 26 minutes. If you would like to show it to executive, employee, social, church or other groups, a request on your letterhead is all that is necessary. Address General Refractories, Philadelphia 2.

GENERAL REFRACTORIES

DOW





Liquid never touches metal in saran lined pipe even at a flanged connection like this.

You can see why Saran Lined Pipe cuts corrosion costs

It's made of corrosion-resistant saran swaged into rigid non-bursting steel . . . liquid never touches metal in these installations

Here's your best way to convey acids, alkalies and other corrosive liquids—saran lined pipe, fittings, and valves. This modern piping is corrosion resistant . . . forms snug, leakproof joints . . . is available for working pressures up to 150 psi. Fittings and valves are also available in steel for working pressures to 300 psi.

Installation costs are low because saran lined pipe can be cut and threaded in the field with available pipe fitter's tools. Its rigidity means few supporting structures are needed.

Saran lined pipe has an outstanding record of trouble-free performance in many industries. THE DOW CHEMICAL COMPANY, Midland, Michigan.

Saran Lined Pipe Company
2415 Burdette Avenue
Ferndale 20, Michigan
Dept. SP626F

Please send me information on saran lined pipe, fittings and valves.

Name _____ Title _____

Company _____

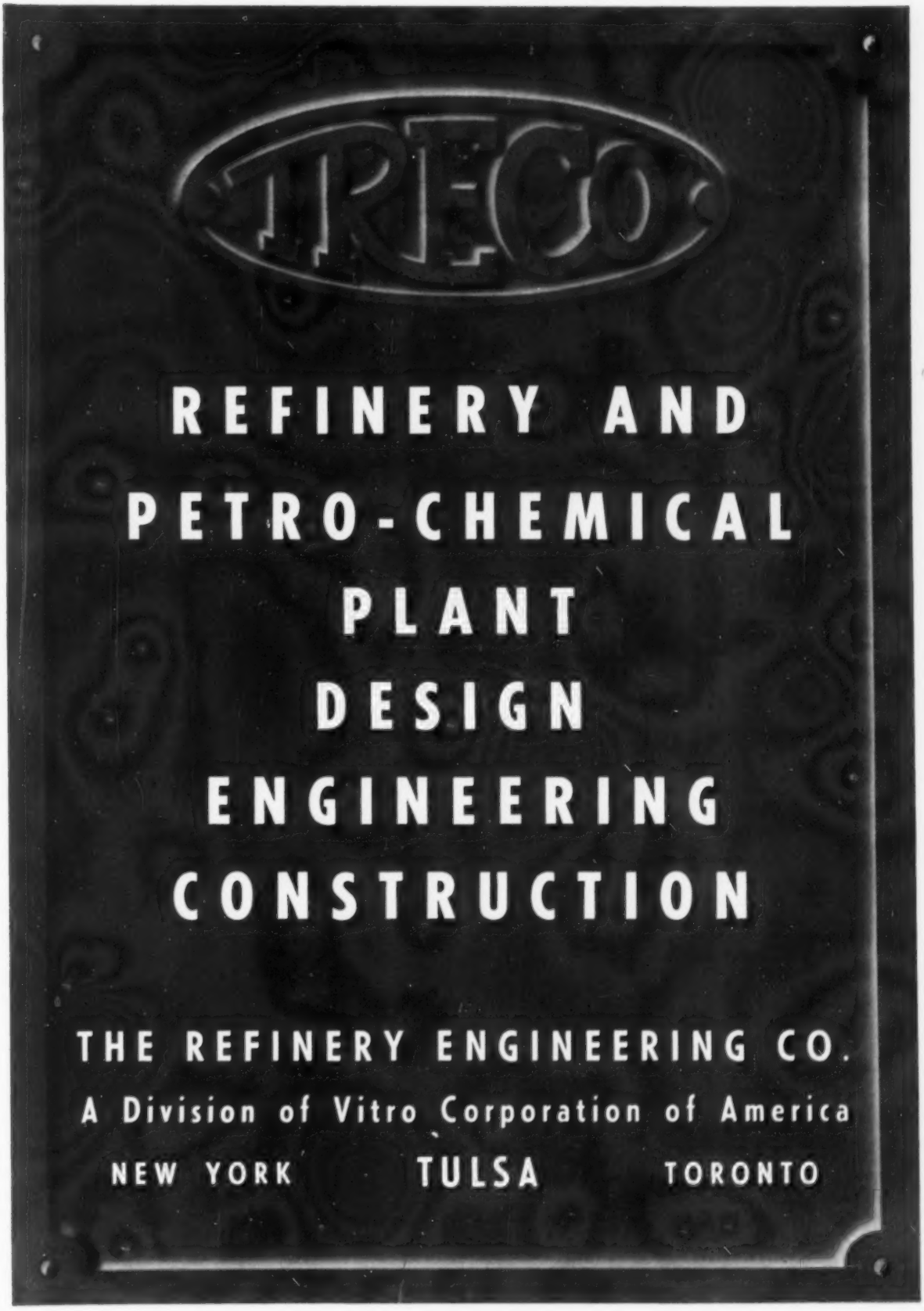
Address _____

City _____ State _____

Saran Lined Pipe is Manufactured by The Dow Chemical Company, Midland, Michigan.

you can depend on DOW PLASTICS

DOW

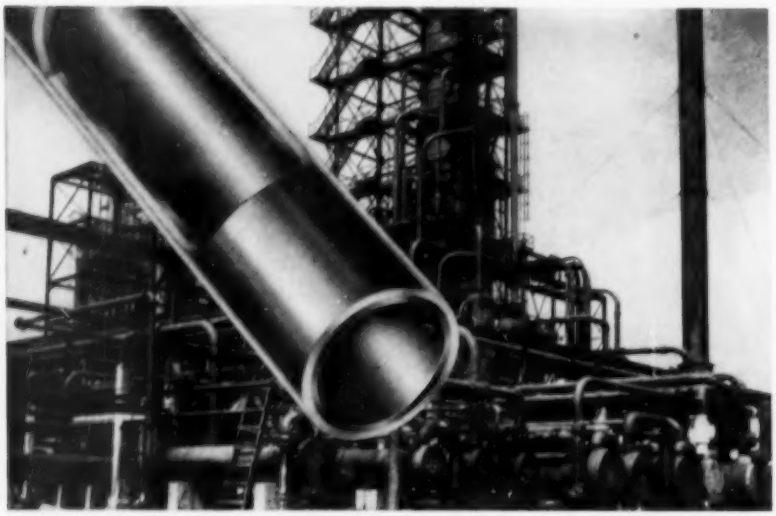

REFINERY AND
PETRO-CHEMICAL
PLANT
DESIGN
ENGINEERING
CONSTRUCTION
THE REFINERY ENGINEERING CO.
A Division of Vitro Corporation of America
NEW YORK
TULSA
TORONTO

BRIDGEPORT BRASS COMPANY

CONDENSER AND HEAT EXCHANGER TUBE EDITION

COPPER ALLOY BULLETIN

Bridgeport Brass Co. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL



The Inside and Outside Story of Duplex Tube

In cases where a different type of corrosion attacks each side of a heat exchanger tube, many users of heat exchanger tubes have found that tubes made of a single metal often are not a solution to both corrosion problems. This is the reason why Bridgeport Duplex Tubes were developed—*because a one-metal tube had not proved itself the universal answer to dual corrosion.*

Bridgeport Duplex Tubes are supplied in more than 100 combinations of ferrous and nonferrous metals. Their economy has been clearly proved. If your heat exchanger tubes are failing to give you all the service life you think you should get, it is very likely that Duplex Tube—which takes advantage of the best qualities of *both* metals—can save you money. Our specialists will be glad to study your problems, and assist in selecting a combination of tube that best fits your needs.

Installation of Duplex Tube is not suggested as the solution to *every* tube problem. But where dual corrosion conditions exist, Duplex Tubes can save money. Before we recommend Duplex Tube, each alloy is carefully selected to withstand the specific corrosion problem on each side of the tube. Pitting or cracking—faults frequently found in certain types of one-metal Tubes—is often eliminated by Duplex Tubes. By gauging the thickness of inside and outside tube walls to the rate of corrosion, longer and uniform tube operating life are assured.

Heat transfer properties of Duplex are often actually better than those of single-wall Tube. This is a result of Bridgeport's method of manufacture which insures a good, tight mechanical bond between the two alloys. The table illustrates why smaller or more efficient heat exchangers are possible with Duplex Tube.

RESULTS OF HEAT TRANSFER TESTS DUPLEX VS. SINGLE WALL TUBE

Steam Condensed on Outside Surface With Fresh Water Passing Through The Tubes

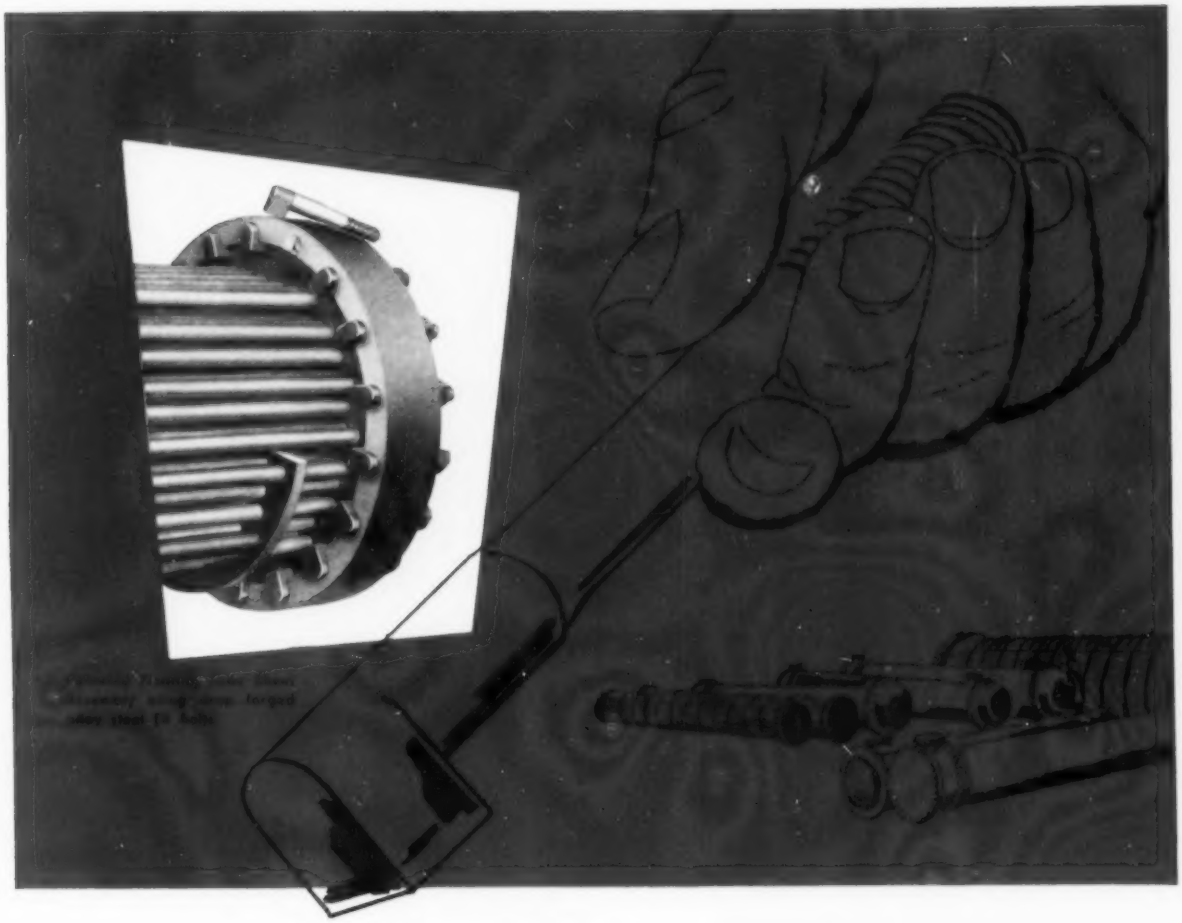
Water Velocity Feet per Second	OVERALL HEAT TRANSFER RATE AT INDICATED WATER VELOCITY BTU/HR./SQ. FT./° F.	
	Duplex Tube ¾" O.D. x Wall Thicknesses .0325" and .0325"	Regular Tube ¾" O.D. x Wall Thicknesses .065"
	Steel to Steel	Steel
2½	371	380
3½	458	458
	Copper to Copper	Copper
2½	580	600
3½	750	740
	Steel to Copper	Steel
2½	465	380
3½	625	458

Heat exchanger tubes that do not give full service life cannot give their operators their money's worth. The service that tubes will give should be balanced by the costs of maintenance, retubing and, of course, the original cost of the tubes. Here, as an example, is the experience of one oil refiner. His first heat exchanger tubes of Low Carbon Steel had lasted only 4 to 5 weeks, and each retubing job cost him more than the tube itself. He then replaced the Low Carbon Steel with another more highly resistant tube, and operating life increased to 3 months. Still not satisfied that he was getting maximum service life for his investment he installed Duplex Tube, stainless steel to the product side and a copper alloy to the cooling side. That was *two years ago*, and his Duplex Tubes are still giving excellent service.

For chemical plants producing colorless formaldehyde, we have supplied Duplex Tubes with Admiralty on one side for brackish water, and aluminum on the outside. For oil refining and natural gas refining, we have made Duplex Tube with steel outside to resist various corrosive vapors, gases and oils; and copper or copper-base alloys inside toward fresh or salt water.

Such experiences with Duplex Tubes have been successful for many years in oil refining, production of synthetic rubber, process industries, chemical plants, coke by-product plants, ammonia production and ammonia refrigeration systems, and other applications. Duplex Tubes have proved repeatedly to be the least expensive equipment over long periods of time because of longer service life and a reduction in frequency of retubing and shut-down periods.

Write today for your copy of Bridgeport Technical Bulletin #1954, describing properties, applications, installation methods and other important Duplex Tube information. (660)



This Ell Bolt is the Key to leak control

The patented Ell Bolt construction employed on Vogt floating head heat exchangers is the answer to re-assembly without distortion or leak development.

Cover may be removed by simply loosening the Ell Bolt nuts and disengaging the Ell Bolt heads from the "lock notches." No misplacing of Ell Bolts can result — and tightening is easy and positive — absolutely leak proof. Send for Bulletin HE-6. Address Dept. 24-XPP.

Vogt

HENRY VOGT MACHINE CO., P. O. BOX 1918, LOUISVILLE 1, KY.

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va., Cincinnati, San Francisco

OTHER VOGT PRODUCTS
Drop Forged Steel Valves, Fittings and Flanges in a complete range of sizes • Petroleum Refinery and Chemical Plant Equipment • Steam Generators • Heat Exchangers • Ice Making and Refrigerating Equipment.

HEAT TRANSFER EQUIPMENT

Costly liquid loss in process vessels with Schuylernit mist eliminators.

Schuylernit (wire mesh) mist eliminators for the chemical and petroleum industries are custom designed and constructed for positive, economical separation of liquid and small solid particles from any gas or vapor. **Recommended for: Vacuum and flash towers . . . gas absorbers . . . evaporators . . . distillation equipment . . . knock-out drums . . . steam drums . . . scrubbers . . . gas filters and compressors.**

Advantages: Increases throughput . . . improves process efficiency . . . eliminates liquid loss . . . reduces vessel sizes . . . reduces contamination . . . improves product quality.

Immediate delivery on round, square or special shapes in any thickness for new or existing equipment. Send for illustrated bulletin 203, Schuyler Manufacturing Corp., 80 Porete Avenue, North Arlington, N. J.

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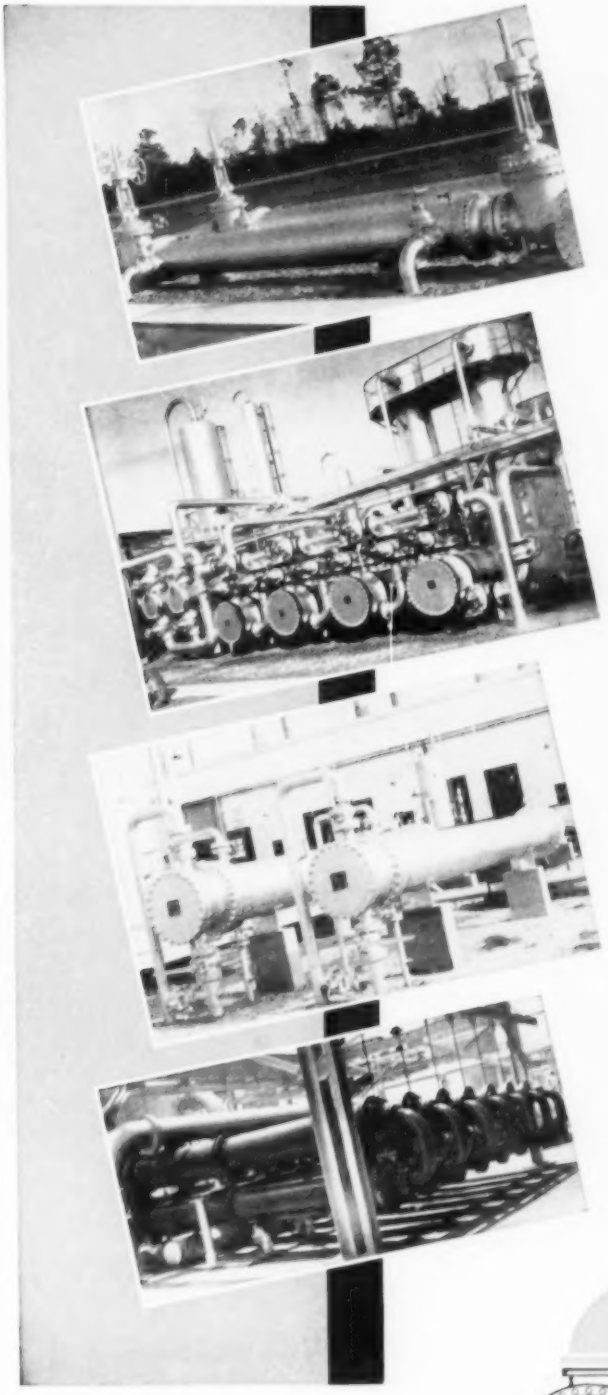
specialists in liquid/vapor separation

SCHUYLER

MANUFACTURING CORP., NO. ARLINGTON, N. J.

(To obtain more data on advertised products see page 182)



Acceptance is the real test of Performance

WESTERN
HEAT TRANSFER EQUIPMENT

Within a relatively short period of 15 years the Western Supply Company of Tulsa has gained national recognition as designers and fabricators of heat transfer equipment for the petroleum, pipe line, chemical processing, and natural gas industries.

The widespread use of Western telescopic exchangers, atmospheric sections, shell-and-tube exchangers, and reboilers, has once again proved that the real test of any equipment is in its acceptance by industry.

Western has gained this acceptance by always doing the job just a little bit better than seemed necessary. Close adherence to rigid engineering codes and specifications . . . modern, up-to-date fabricating equipment . . . trained, experienced personnel . . . . plus a willingness to work cooperatively with the customer — these are the elements of PERFORMANCE that have assured industry ACCEPTANCE of Western produced heat transfer equipment.

We invite you to consult with us on all your heat exchanger needs. Detailed information on our fabricating facilities will gladly be forwarded upon your request.

Sales Representatives—

HUDSON-RUSH COMPANY
753 Gladstone Blvd., Shreveport, La.
130 Casa Linda Plaza, Dallas 18, Tex.

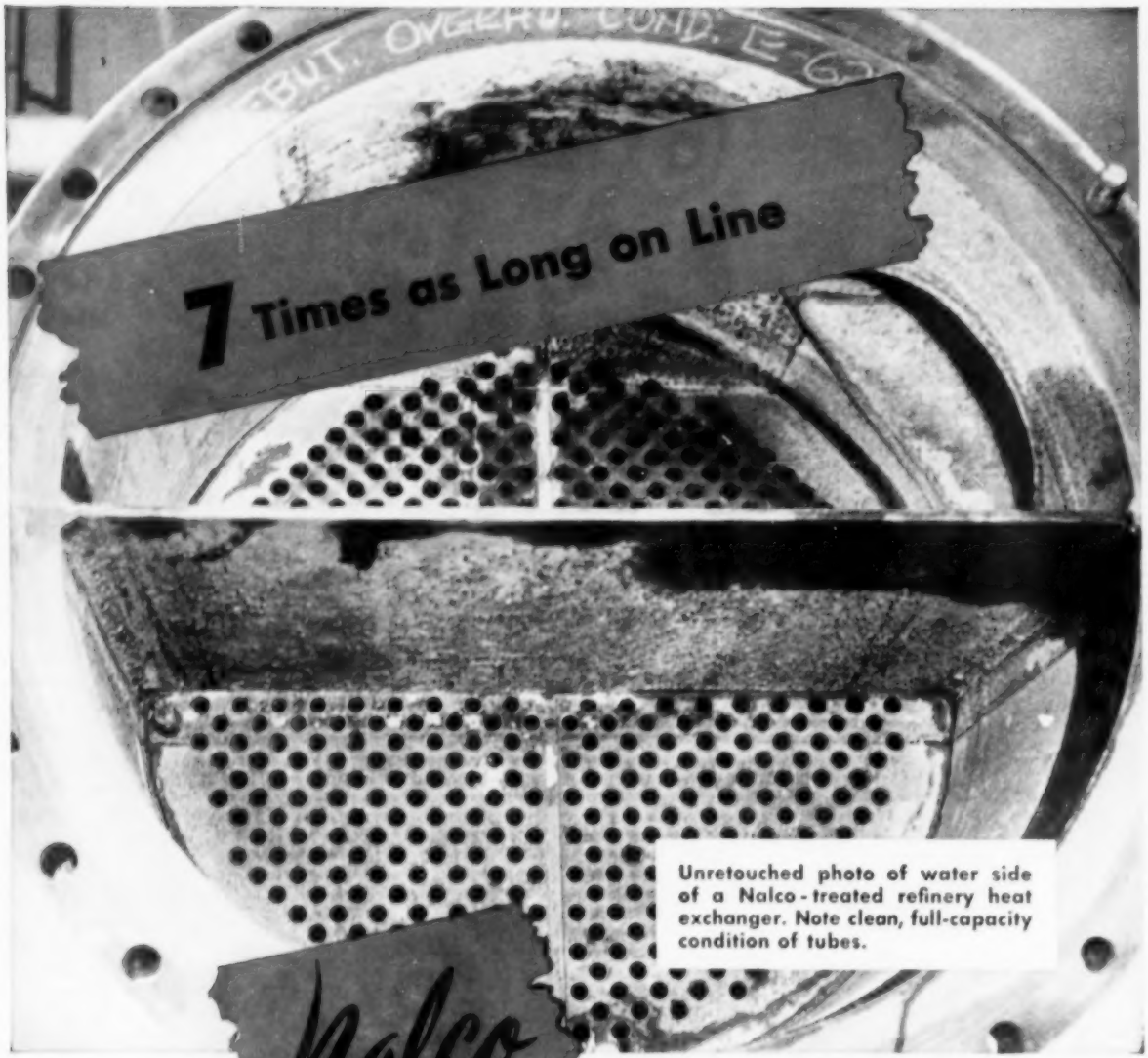
PROCESS INSTRUMENTS & EQUIP. CO.
North Bldg., Charleston, W. Va.

H. W. SEVERANCE
Marion E. Taylor Bldg.
Louisville, Ky.

WESTERN
HEAT EXCHANGERS

Manufactured by
WESTERN SUPPLY COMPANY
P.O. BOX 1888 TULSA, OKLAHOMA
SALES OFFICES — DALLAS — HOUSTON

(To obtain more data on advertised products see page 182)


7 Times as Long on Line
Unretouched photo of water side of a Nalco-treated refinery heat exchanger. Note clean, full-capacity condition of tubes.

SINCE Nalco TREATMENT TOOK OVER

This refinery heat exchanger was a prize example of plugging and corrosion headaches before Nalco System treatment was applied to the cooling water. After *7 times as long* as average previous runs, the exchanger was opened for inspection and found clean and corrosion free.

Consider your system. How much would you save by drastically cutting . . . perhaps even eliminating . . . the number of manual or mechanical cleanings of heat exchangers? Certainly it is substantial . . . more than enough to warrant writing or calling, TODAY, for more information from Nalco.

NATIONAL ALUMINATE CORPORATION

Telephone POrtsmouth 7-7240
6258 W. 66th Place • Chicago 38, Illinois
In Canada: Alchem Limited, Burlington, Ontario

THE Nalco® SYSTEM . . . Serving Industry through Practical Applied Science

Reduce Down-Time Costs

with ROCKWELL-Nordstrom VALVES

The two most common valve problems that cause excessive down-time costs are seat failure (leakage) and wear. Performance records in thousands of refineries and gasoline plants prove that Rockwell-Nordstrom valves cut down-time costs because they *stay leakproof* and *wear longer in service* than any other valve. In Rockwell-Nordstrom valves, there are no exposed seats to be cut-out or corroded. Leakproof, positive shut-off is assured by pressurized lubricant sealing. Lubricant also eliminates the metal-to-metal friction that causes ordinary valves to wear out so quickly.

The low maintenance cost and dependability of Rockwell-Nordstrom valves is a matter of record, yet they cost no more to buy, often less, than ordinary valves. Available in a complete range of sizes and pressure ratings. Write today for more information: Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee: Peacock Brothers Ltd.

ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-Off

40th YEAR *of lubricated plug valve leadership*

SHELL Launches New Safety Series

All over the country people are seeing Shell Better Driving Quizzes like the one on the right and those below.

Behind this new campaign lies Shell's conviction that part of our job—as a major supplier of gasoline and oil products—is to promote driving safety. That's why Shell started the famous "Share-the-Road" club back in the late 1930's. That's why we established the Carol Lane Awards for women's efforts toward traffic safety.

This new safety series urges the reader to test his reflexes, eyesight, knowledge of road signs, driving attitudes. No longer can the reader shrug off a safety message as written for "the other fellow." First indications are that these advertisements actually are helping many drivers think more seriously of their highway habits. That's a sure sign of a better future for all of us.

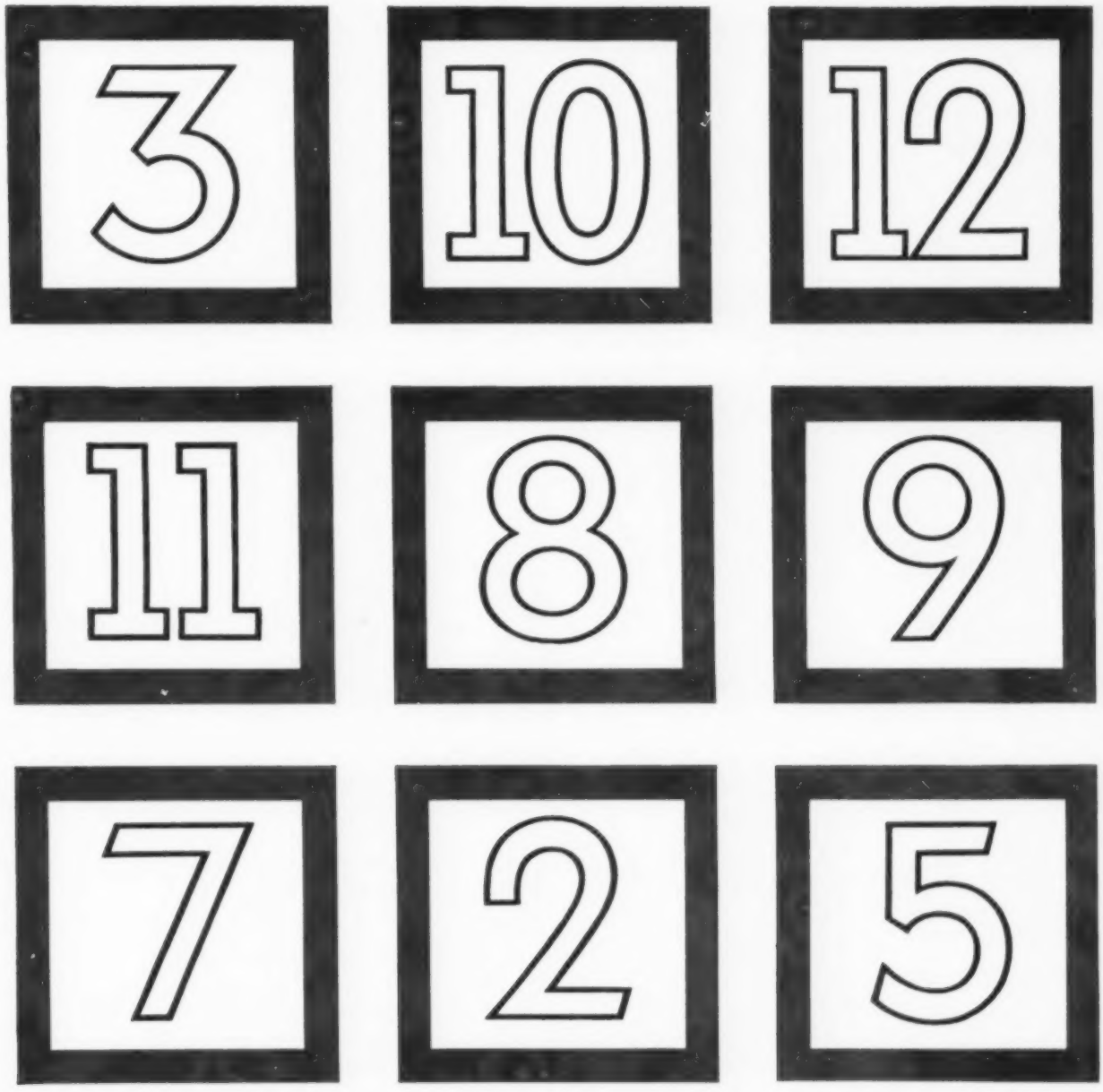
Can you tell a road sign by its shape?
Read and obey your signs of life!
SHELL OIL COMPANY
How far from the car in front should you be at 50 mph?
Stay Back! Don't Crowd Your Luck!
SHELL OIL COMPANY
See how fast you can move to the brake!
BRAKE
GAS
SHELL OIL COMPANY
Check your driving attitudes
STOP
Drive right...enjoy your right to drive
SHELL OIL COMPANY

TRY THIS BETTER DRIVING QUIZ!

It helps you relate your reaction time to safe driving speeds. Others in Shell's public service series on driving safety highlight such factors as courteous attitudes and recognition of road signs.

SHELL

(To obtain more data on advertised products see page 182)



HOW FAST CAN YOU TOUCH EACH SQUARE IN NUMERICAL ORDER?

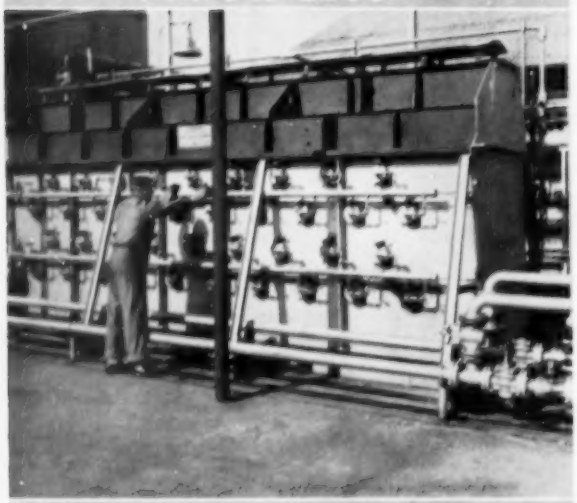
WITHIN 9 SECONDS? Your reflexes are about average.
WITHIN 7 SECONDS? Very good.
WITHIN 5 SECONDS? Excellent.

MORE THAN 9 SECONDS? YOUR REFLEXES ARE TOO SLOW. DON'T DRIVE OVER 45 M.P.H.*

©1956

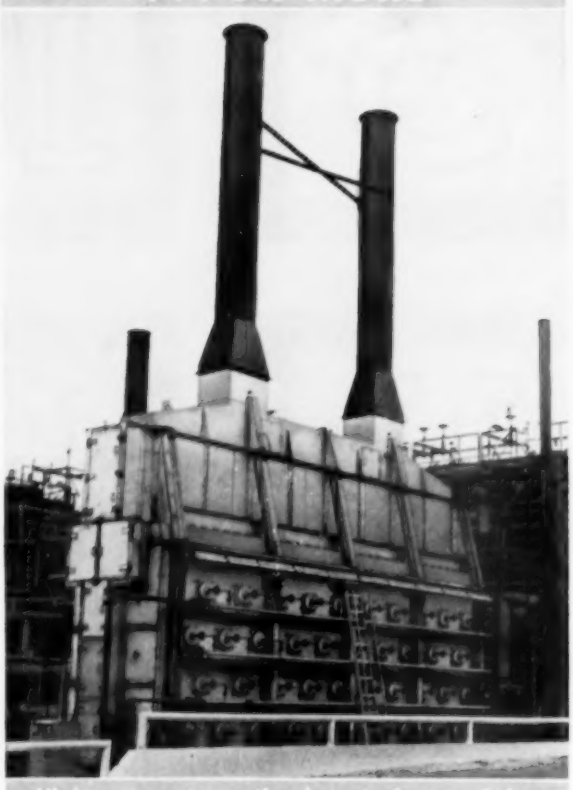
*Authority Dr. Herbert J. Stack, Director, Center for Safety Education, New York University

1/2 MILLION BTU's ... OR LESS



Acetone pyrolysis in a chemical plant

35 MILLION BTU's ... OR MORE



High-vacuum operation in petroleum refining

. . . same Flexibility, Uniform Heating, Precise Control with Selas Gradiation® Heating

Size is no limitation to the advantages of Selas Gradiation Heaters and Zone Control.

For pilot plant or volume production . . . whether your *petroleum refining*, *petrochemical* or *chemical processing* operations involve critical pyrolysis reactions . . . controlled catalytic reactions in packed tubes . . . or high temperature preheating . . . you get the same benefits of Selas Zone Control:

- *Uniform peripheral heat distribution around the tubes assures elimination of local overheating . . . minimized material degradation at the tube wall . . . greater tube life.*
- *Zones of controllable heat input produce the desired time-temperature curve . . . permit most effective use of the surface provided.*
- *Controlled combustion means no external oxidation of the tubes . . . no lag in response to controller demand.*

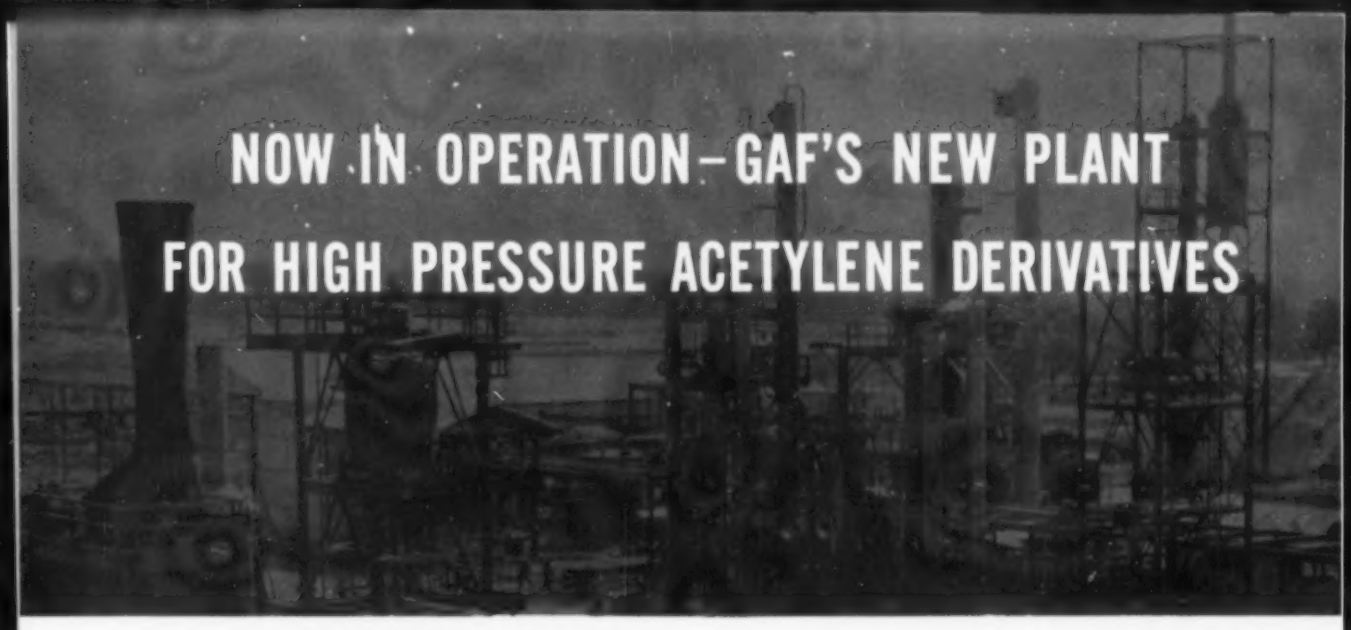
Selas Gradiation Heating offers new possibilities in every petroleum and chemical plant where heat processing is a precise operation.

Send for informative bulletin No. 93 "Gradiation Heating for Petroleum and Chemical Processing."

SELAS CORPORATION OF AMERICA DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers

DEVELOPMENT • DESIGN • CONSTRUCTION



NOW IN OPERATION–GAF'S NEW PLANT FOR HIGH PRESSURE ACETYLENE DERIVATIVES

the story behind the headline

For those of you who have not been eating, sleeping and breathing high pressure acetylene reactions as we have, a brief reminder on the background of these products may be in order. In the early 1930's, Dr. J. Walter Reppe, working in Germany, licked the previously "impossible" problem of handling acetylene efficiently and safely at high temperatures and high pressures in chemical syntheses. This led him and his group into varied investigations which resulted in the synthesis of numerous chemicals which had previously been completely unknown, or at best only obtainable by elaborate and expensive reactions.

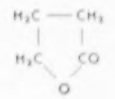
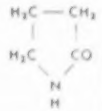
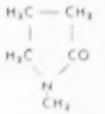
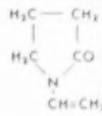
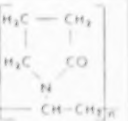
Even though widespread work in this field has continued steadily up to the present, and the laboratories of General Aniline in this country have been engaged in their own independent research for more than ten years, vast and challenging areas of research still remain for exploration in the new branch of chemistry involving high pressure acetylene reactions.

When the GAF laboratories began synthetic work in the new field, none of the products they turned out had ever been available in the U.S. in commercial volumes and at commercial prices. We, therefore, found it necessary to do some rather fancy, long-range extrapolating from the physical and chemical properties of all of the products to their potential applications and sales volumes in order to decide which would be of greatest immediate industrial value. Following these decisions came sales development, application research, and process development in the laboratory and pilot plant. Finally, the plant stage has been reached for the first group of products now to be made at GAF's new Calvert City plant.

They are a related series resulting from the reaction of acetylene with formaldehyde to yield a mixture of butynediol and propargyl alcohol. In a relatively brief time they have developed an astonishing and, we must confess, in part unexpected range of applications about which GAF's Commercial Development Department has told you in advertisements, data bulletins and personal visits. Along with the large new plant now also comes a new, full-scale sales department eager to help you use these products to your best advantage.

We expect to be reporting the commercialization of many more high pressure acetylene derivatives in the future, but no announcement will have quite the significance of this first one, both for you and for us. We believe it represents a milestone for our industry: the first of many commercial high pressure acetylene derivatives plants in the United States.

PRODUCTS TO BE AVAILABLE FROM GAF's NEW PLANT AT CALVERT CITY, KENTUCKY:

PROPARGYL ALCOHOL $HC{\equiv}CCH_2OH$	2-BUTYNE-1,4-DIOL $HOCH_2C{\equiv}CCH_2OH$
1,4-BUTANEDIOL $HOCH_2CH_2CH_2CH_2OH$	BUTYRO-LACTONE 
2-PYRROLIDONE 	N-METHYL-2-PYRROLIDONE 
N-VINYL-2-PYRROLIDONE 	POLYVINYL-PYRROLIDONE (PVP) 

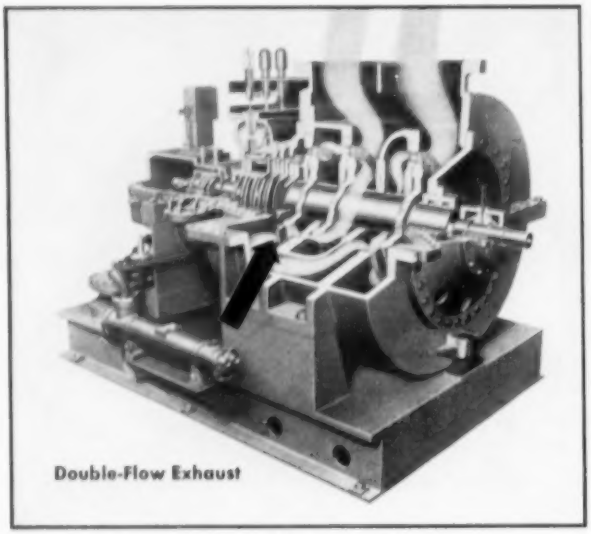
For technical information, price schedules and samples write to:

ACETYLENE CHEMICALS DEPARTMENT
ANTARA CHEMICALS
A SALES DIVISION OF
GENERAL ANILINE & FILM CORPORATION
435 HUDSON STREET · NEW YORK 14, NEW YORK

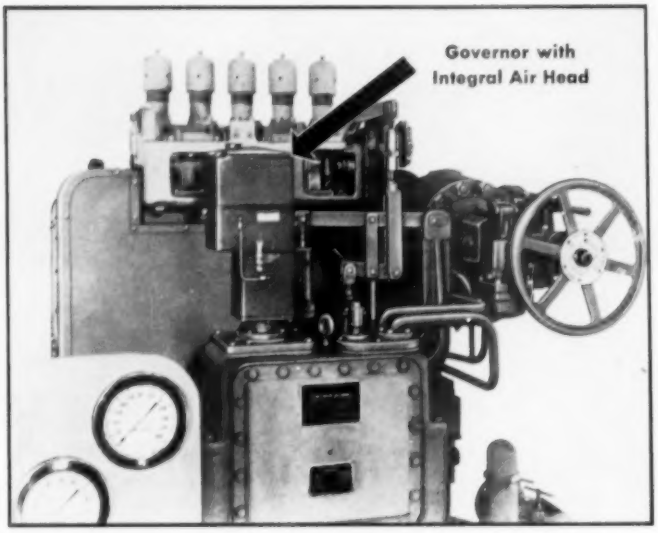
ANTARA
gaf

From Research to Reality

In high-speed turbines . . . why does in total horsepower and



GREATER RELIABILITY. Worthington's rugged construction pays off in extra reliability. Solid rotor for modern high speeds, double-flow exhaust where large volumes of steam are used in condensing operation, and Kingsbury type thrust bearings are just a few of the features that assure safety and dependable service on your vital compressor and blower drives.



ACCURATE SPEED REGULATION. Exclusive Worthington governing system using governor with integral air motor gives you speed control response to .04 psi change in control pressure. And it provides for remote automatic operation if you need it. The oil relay type governor so equipped instantaneously controls pressure or volume delivered by the compressor regardless of steam variations.

Where turbine-driven compressors and blowers are used, down-time is usually mighty expensive. Particularly so if failure can bring a continuous process to a standstill. In the case of high-speed/high-horsepower compressor-drive turbines, your surest way to design reliability into your plant is to specify the turbine line with best *proven* performance.

Compressor-drive turbine installations up to 12,000 rpm, and 24,000 hp, show Worthington leads in application engineering, design, reliability.

Worthington compressor-drive turbines are conservatively built with all stresses carefully calculated and kept well within established safety margins. Also, measured load tests are performed on every unit at the factory with modern facilities, under the watchful eyes of highly trained personnel.

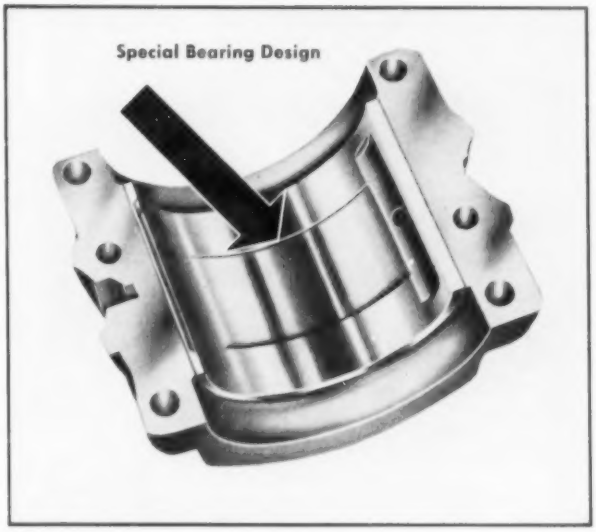
One feature seldom claimed is that of lowest price. That is inconsistent with quality, and quality is something Worthington engineers will not compromise. For critical operations, buying the best is lowest cost insurance against process equipment failure.

Get the complete story of high-speed/high-horsepower compressor-drive turbines by writing Worthington Corporation, A&SP-Turbines, Harrison, New Jersey. Ask for your personal copy of Bulletin 1966.

On Vital Compressor and Blower-Drive Applications . . . It Costs Less to Invest in the Best!

WORTHINGTON

WORTHINGTON lead all others number of installations?

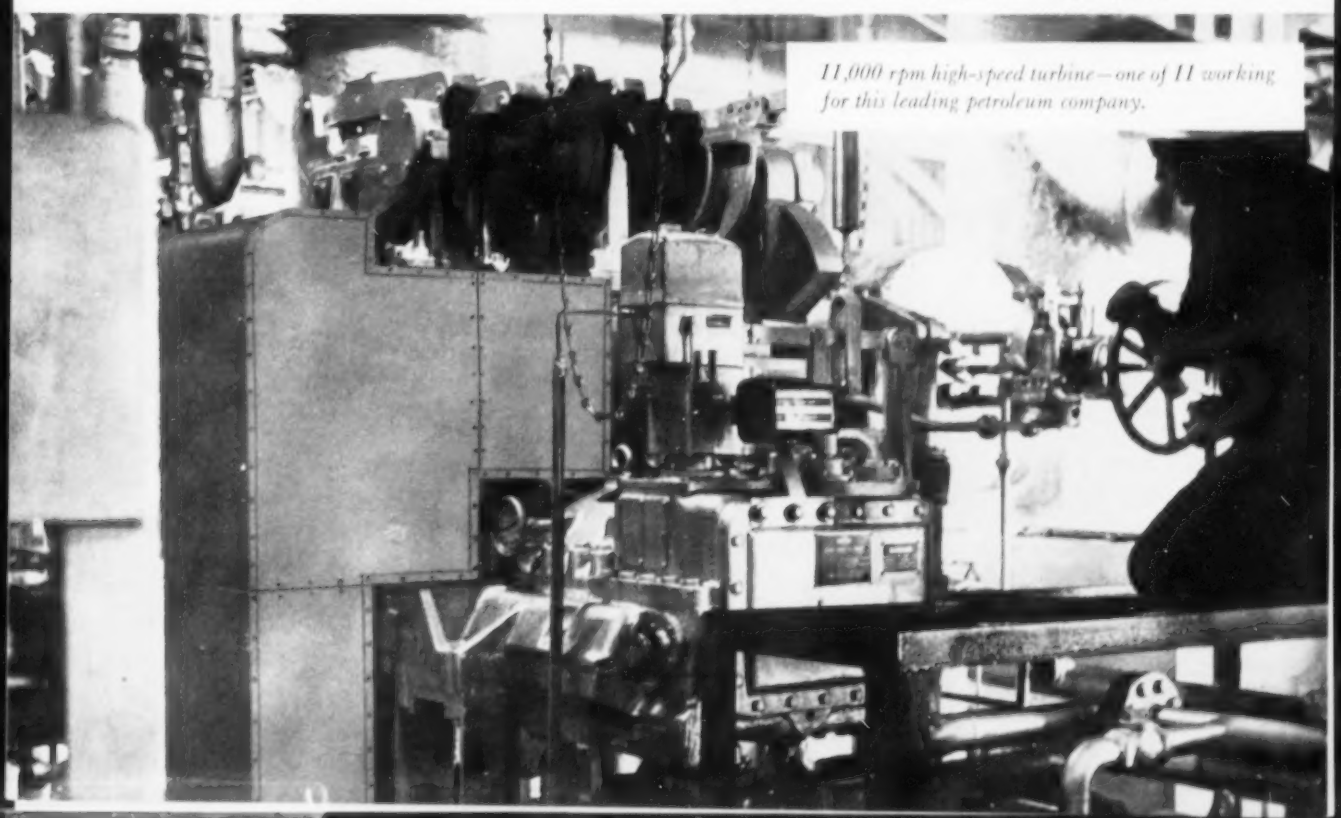


To meet turbine spec's. 4000 Hp- 7250 RPM -Steam 210 #-550°-26½"
WORTHINGTON GIVES YOU ALL THIS—CHECK AND COMPARE:

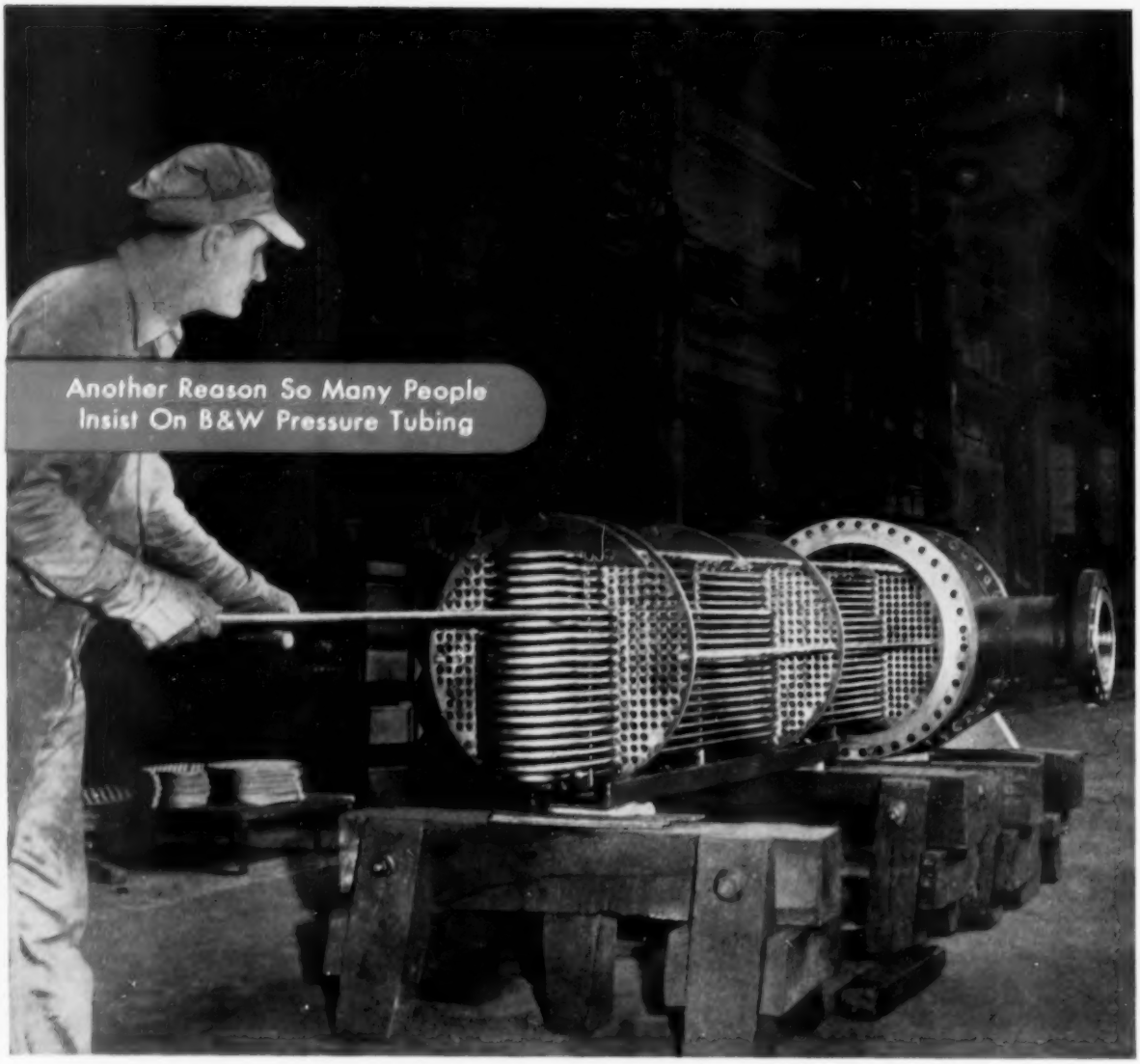
	Feature	WORTHINGTON	Company A	Company B	Company C
Rotor	Solid—to withstand extreme stresses.	✓			
Main Bearings	Anti oil-whip—for longer turbine life.	✓			
Thrust Bearing	Kingsbury type—for proven reliability.	✓			
Automatic Nozzle Control	Cam operated—for economy and better control.	✓			
Governor	Has integral air motor—for more accurate control.	✓			
Type Construction	Double flow exhaust for economy and long life.	✓			
Packing	Labyrinth—for most effective seal at high speed.	✓			
Test	Load test—to be sure you get what you ordered.	✓			

LOWER MAINTENANCE COST. One important example of construction used to help eliminate non-scheduled maintenance is Worthington's anti oil-whip bearing. During operation a pocket (arrow) in the upper half of the bearing builds up a pressure pad of oil. High pressure here creates a downward force on the journal, holding it in place in the bearing, preventing destructive vibration.

LONGER LIFE. A long, trouble-free life can be attributed to no *one* turbine feature, but rather a combination of many engineering advances. Compare design features yourself, one by one. Far ahead of any other manufacturer in the compressor-drive field, Worthington's first compressor-drive turbine built in 1927 is still working around the clock, in a large Eastern gas plant.



11,000 rpm high-speed turbine—one of 11 working for this leading petroleum company.



TALK ABOUT TOLERANCES!!

In oil fields, refineries, chemical plants—wherever heat transfer is important—you'll find Griscom-Russell heat exchangers on the job. The Griscom-Russell Company uses B&W Pressure Tubing to help build its reputation for efficient equipment. There's no jamming or tube distortion when threading B&W tubing through tube sheets and baffle plates. This preoccupation with close tolerances—a workaday rule at both B&W and Griscom-Russell—assures closer control, greater efficiency in many heat transfer operations. In addition, B&W Pressure Tubing is famous for uniform ductility, tight joints, ease of rolling in, and low installation cost in any heat exchanger or condenser application.

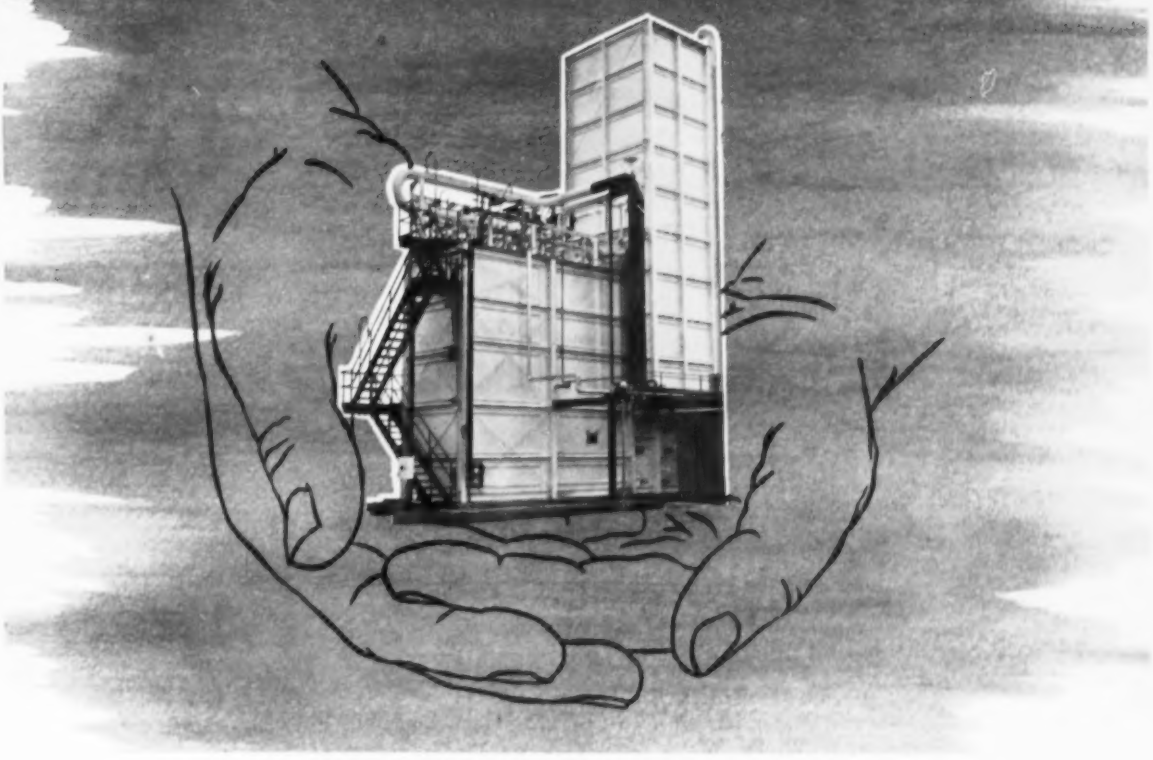
For the complete story of how B&W Pressure Tubing can improve your operation, why not call in Mr. Tubes, your link to B&W. *Or write today for Bulletin TB-329-PP.*

B&W
TUBULAR PRODUCTS DIVISION

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa. and Milwaukee, Wis.: Seamless Tubing, Welded Stainless Steel Tubing
Alliance, Ohio: Welded Carbon Steel Tubing
Milwaukee, Wis.: Seamless Welding Fittings

TA-5022(P)

An Air Products "ON-LOCATION" GENERATOR keeps your OXYGEN-NITROGEN supply always in your hands



If your processes require oxygen or nitrogen in volume, your own "on-location" generator can be a tremendously profitable investment. With the free air for raw material, it can substantially reduce the cost of your end product and eliminate all uncertainty regarding your oxygen or nitrogen supply.

We are prepared to design and build for your requirements:
Large Capacity Tonnage Generators, regardless of size, purity, or cycle, with liquid pumps

or

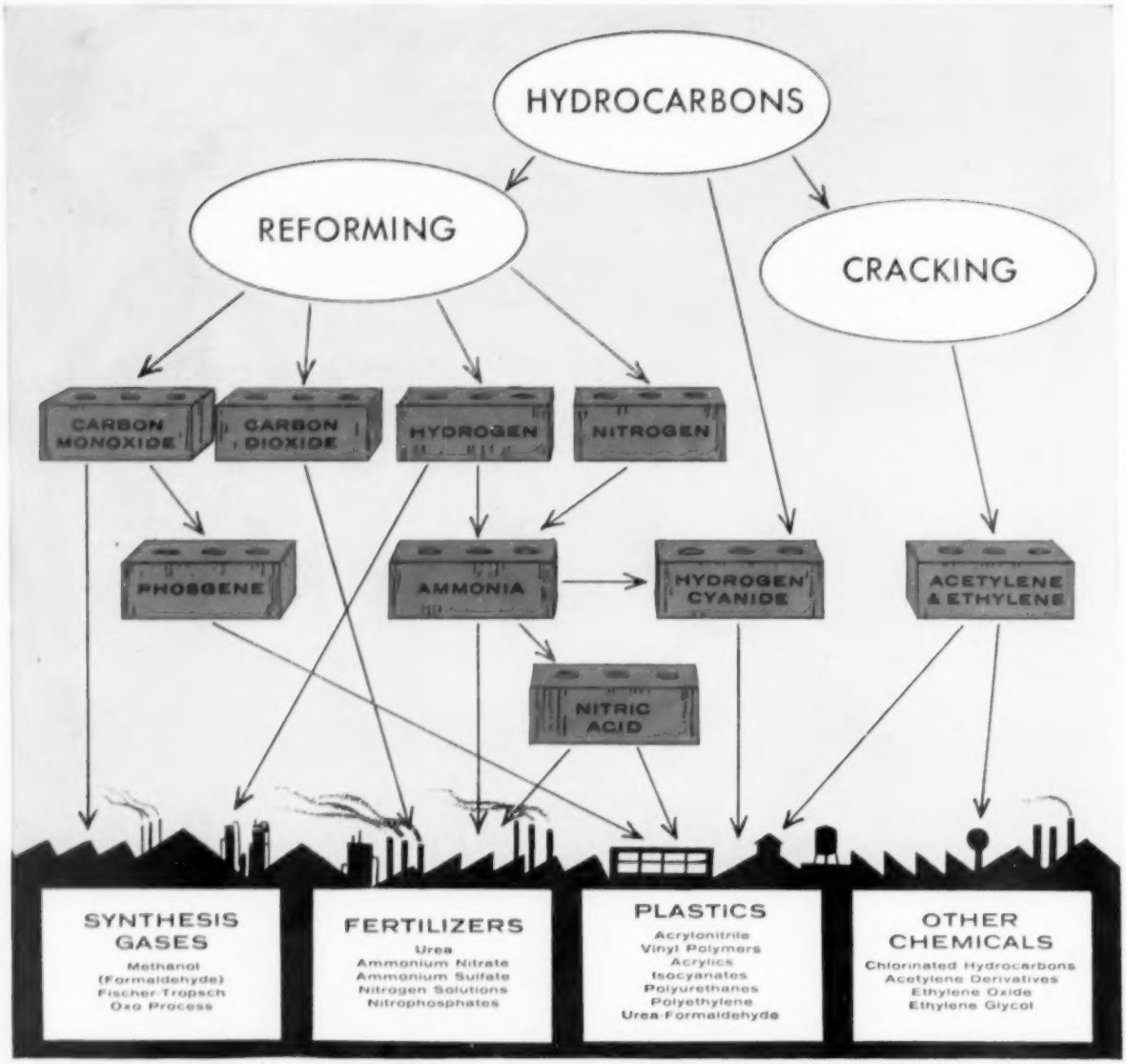
"Packaged" High Purity Generators, producing high purity oxygen and nitrogen simultaneously
—delivered safely under pressure by Air Products patented liquid pumps.

Make this oxygen-nitrogen source a member of your production family and save money. Consult us for comparison of costs.

More than 700 successful installations

Air Products
INCORPORATED
Dept. L Box 538, Allentown, Pa.

Cost Analyses
Process Design
Apparatus Design
Apparatus Manufacture



Building blocks for chemical expansion ...produced with GIRDLER plants

These nine basic intermediates made from hydrocarbons, and some of the end chemicals, are produced with Girdler plants. Here is another indication of Girdler's broad experience available to you for the expansion of your processing facilities.

Girdler assumes responsibility for designing, engineering and construction of process plants for these synthesis gases . . . and many other products. Take advantage of Girdler's vast experience when you *start* to plan your processing facilities!

The GIRDLER Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION: New York, San Francisco • **VOTATOR DIVISION:** New York, Atlanta, Chicago, San Francisco
In Canada: Girdler Corporation of Canada Limited, Toronto

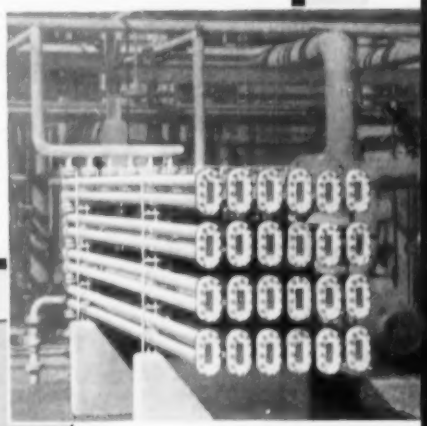
(To obtain more data on advertised products see page 182)

Prevent this Waste!

BROWN FINTUBE

SECTIONAL HEAT EXCHANGERS

Eliminate Obsolescence and Waste in . . .



PILOT PLANT, SEMI WORKS and FULL PLANT OPERATIONS

● Modular design;—can be changed quickly from one product and duty to another by simply adding or removing sections or changing series-parallel manifolding. Pilot operations enlarged easily to semi-works or full plant by direct multiplication keeping all conditions in same relationship. Standard sizes. Interchangeable. Pressures to 22,000 psi. Mild steel, alloy or non-ferrous construction.

HEAT EXCHANGE SURFACE
BROWN FINTUBE
HEAT TRANSFER PRODUCTS

BROWN FINTUBE COMPANY

Elyria, Ohio

Engineering and Sales Representatives in the Principal Cities

. . . there's enough difference to make ALL the difference

This is just one inspection of extrusion dies through which a cast billet heated to a rigidly controlled temperature is hot extruded into a "tube shell" . . . from which Scovill Heat Exchanger Tube is subsequently cold-drawn.

One of the most highly skilled and critical jobs in the process is that of finishing and maintaining these dies. The smooth, clean surfaces of resulting shells are essential assurance of highest quality in finished tubes.

It is needless to tell Scovill customers that, while *correct alloy selection* is important to efficient exchanger operation, of equal importance is the *uniformity and soundness of tubes* themselves. Scovill Technical Service and tube production methods, considered by many the very best in the industry, can give you complete assurance on both these essential counts.

Scovill Heat Exchanger Tube is available in a comprehensive range of standard alloys (listed below).

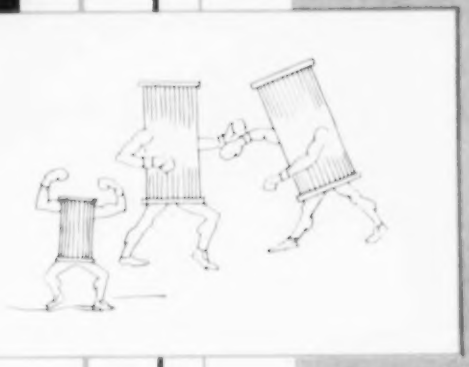
Scovill Manufacturing Company, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone Plaza 4-1171.

SCOVILL **HEAT EXCHANGER TUBE**

Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Muntz Metal • Naval Brass • Red Brass, 85% • Deoxidized Copper
Arsenical Copper • Copper Nickel, 10% & 20% • Cupro Nickel, 30% • Aluminum Brass • Aluminum Bronze, 5% • Duplex Tube

 (To obtain more data on advertised products see page 182)

THE CASE OF THE BANTAM STAND-BY



"There was no doubt about it. Paul Jones was completely dumbfounded." "Just a minute," he screamed. "Do you mean to stand there and tell me that undersized little condenser is your stand-by unit? It's impossible. It's almost a third smaller than your on-stream units. It couldn't possibly carry the same heat load when you switch over."

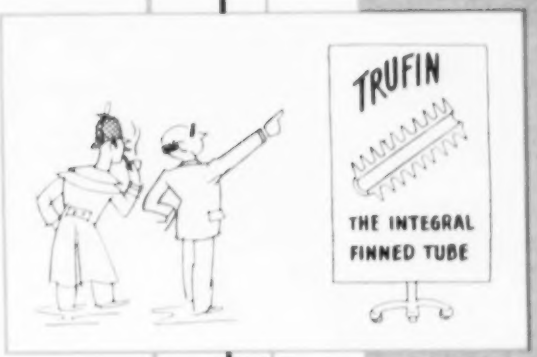
"I couldn't help laughing to myself. Paul is a processing engineer—a good one, too. Home-office had sent him out to see just how come we were able to out-produce the east-coast plant. Basically, both installations are the same—but for the past year our production records have been away ahead of theirs. I had him out on an inspection trip—showing him our set-up.

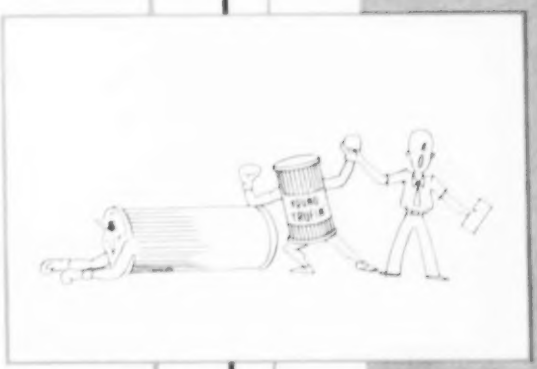
"Paul", I said, "you'd make a good private eye. You spotted that size differential fast! Strange as it seems—that's the secret of our high production. It all started about the time this plant first went on stream. A Wolverine salesman was making a call just as I was going over the prints for our stand-by unit."

"Look," he said. "On this job, if you use Wolverine Trufin —the integral finned tube—you can design a smaller unit. Trufin is an extended surface tube with its fins extruded right from the tube wall. It has over twice the surface area of prime surface tube. As a result you get increased heat duty from a smaller unit plus a substantial saving in tubing costs."

"Well, we designed the stand-by around Trufin Type S/T—and it worked just like he said it would. Naturally ever since then, when we pull a unit for retubing, we use nothing but Trufin Type S/T. That increased heat transfer surface is boosting our capacity—that's why our production has been ahead of yours."

And there you are! To achieve exactly the same kind of results in your own processing installation, specify Wolverine Trufin Type S/T. Write, too, for your copy of the Trufin Opportunity Book—64 pages—full of actual Trufin case histories and helpful design information.





WOLVERINE TUBE, 1441 Central Avenue, Detroit 9, Michigan.

WOLVERINE TUBE
Division of Calumet & Hecla, Inc.

MANUFACTURERS OF QUALITY CONTROLLED TUBING AND EXTRUDED ALUMINUM SHAPES

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK

TRUFIN*

SAVES YOU MONEY

8 WAYS

Anytime you cut down costs, you pep up the profit picture. Here's an idea: where heat exchange costs are concerned, Wolverine Trufin Type S/T—the integral finned condenser tube—can help you save money *eight* ways. Take a look at the points listed below. They can open the door to substantial savings, provide added dividends in increased efficiency.

✓ Because Trufin is an extended surface tube—with fins extruded right from the tube wall—it has more than twice the heat transfer surface of plain tube. Less tube is required because Trufin transfers more BTU's per foot of tube.

✓ Fewer tubes mean smaller shells, headers, baffles, etc. This saves material requirements.

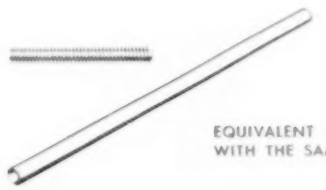
✓ Fewer tubes mean fewer holes to drill—less rolling-in operations. Direct result: substantial savings in labor costs.

✓ To transfer a given heat load—when Trufin is used—much less weight of over-all tube metal is required. This is a real saving when expensive alloys are necessary. This is of greatest importance when alloys are in short supply, as a given quantity of metal in Trufin transfers much greater heat loads.

FEWER TUBES
MEAN SMALLER SHELLS

✓ Because of these material savings, lighter units—requiring less structural support—can be designed. This is vital when exchangers are to be mounted on superstructures.

✓ Maintenance costs are low. Costs of replacement tubes are reduced; fewer tubes result in less cleaning time, more "on stream" time. Actual operating data proves that Trufin withstands fouling for longer periods than does prime surface tube. This increases the length of operating time between change-overs.



EQUIVALENT TUBES
WITH THE SAME SURFACE

✓ Smaller, lighter units result in easier handling and lower shipping costs.

TRUFIN
MEANS
SMALLER
UNITS

✓ Where space is at a premium—as in revamped units—Trufin units are smaller.

There they are—eight job-proven ways in which Wolverine Trufin Type S/T condenser tube can save you money. Wolverine's Trufin Opportunity Book is filled with actual Trufin case histories, operating data, valuable design information. Write for your copy today. WOLVERINE TUBE, 1441 Central Avenue, Detroit 9, Michigan.

Wolverine Trufin available in Canada through the Unifin Tube Company, London, Ontario

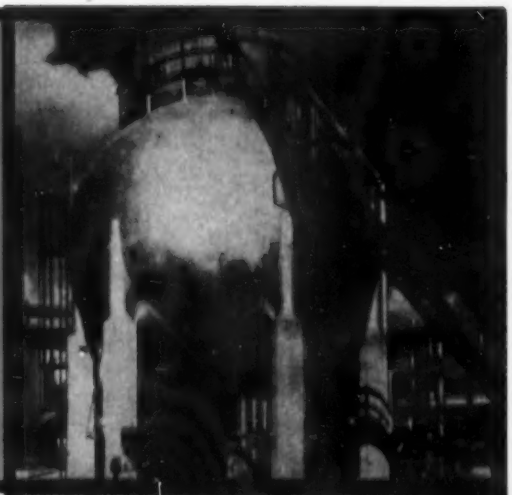
WOLVERINE TUBE
Division of Calumet & Hecla, Inc.

*REG. U. S. PAT. OFF.

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK

WHY IS PETRECO-DESALTED CRUDE A SAFER REFINERY CHARGE THAN A NON-DESALTED "LOW-SALT" CRUDE?



Even "low-salt" crude causes trouble. The trend in desalting performance is increasingly toward maximum removal, minimum residual salt.

Petreco desalting provides removal percentages in the 98 to 100% range, with residual salt averaging 1.5 ptb, and less.

A "low-salt" crude often contains solids such as sand, silt, rust and other plugging or abrasive materials to such a degree that they are more troublesome than salt.*

Petreco desalting effectively removes such solids and fines.

A refinery operation planned on a "low-salt" charge is greatly upset if it becomes necessary to charge a salty crude.

Petreco desalting insures smooth operations regardless of the salt and solids content of the crude charge. Petreco desalting has effectively desalted every crude charged to it.

Minute quantities of arsenic can be present in any crude, "low-salt" or otherwise, and severely impair catalysts.

Petreco desalting reduces arsenic, stops catalyst poisoning.

Regardless of salt content, "slugs" of water are sometimes picked up in the crude charge when tanks are switched. Such water-slugs play havoc with distillation equipment.

Petreco desalting eliminates the hazard of water "slugs."

The storage of crude oils in the refinery often results in the deposition of "tank bottoms." These bottoms displace storage capacity, and cause an expensive disposal problem.

With Petreco desalting in the refinery, tank bottoms can be metered into the crude charge and easily disposed of.

*In one refinery, usually charging crude containing only 5 ptb, Petreco desalting showed a rapid pay out solely on the basis of solids removed.

6 REASONS WHY PETRECO DESALTING IS PREFERRED BY SO MANY LEADING REFINERS

1 [illegible]

2 [illegible]

3 [illegible]

4 [illegible]

5 [illegible]

6 [illegible]

ELECTROFINING

PETRECO

A DIVISION OF PETROLITE CORPORATION

3202 SOUTH WAYSIDE DRIVE, HOUSTON 1, TEXAS • 1390 EAST BURNETT STREET, LONG BEACH 6, CALIFORNIA

DS-9

ALUMINUM

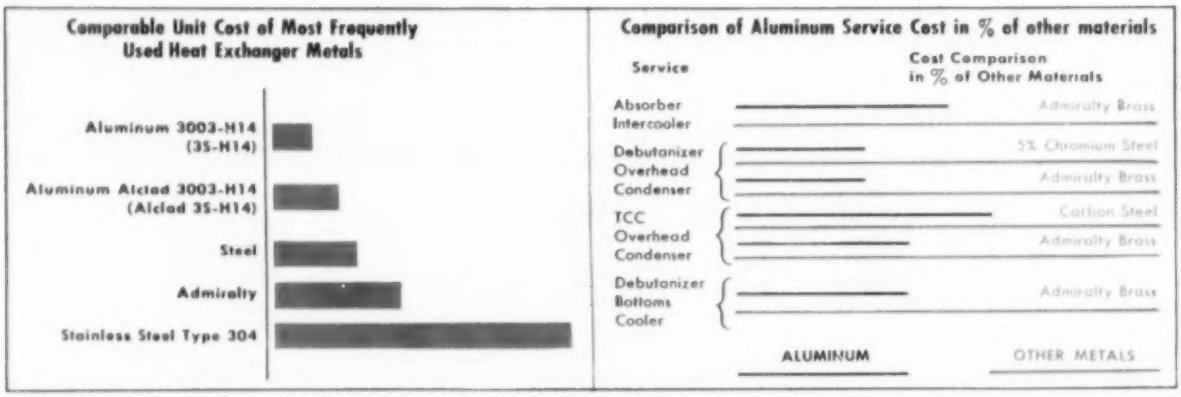
...the heat exchanger tubing that COSTS LESS, resists corrosion, provides maximum heat transfer

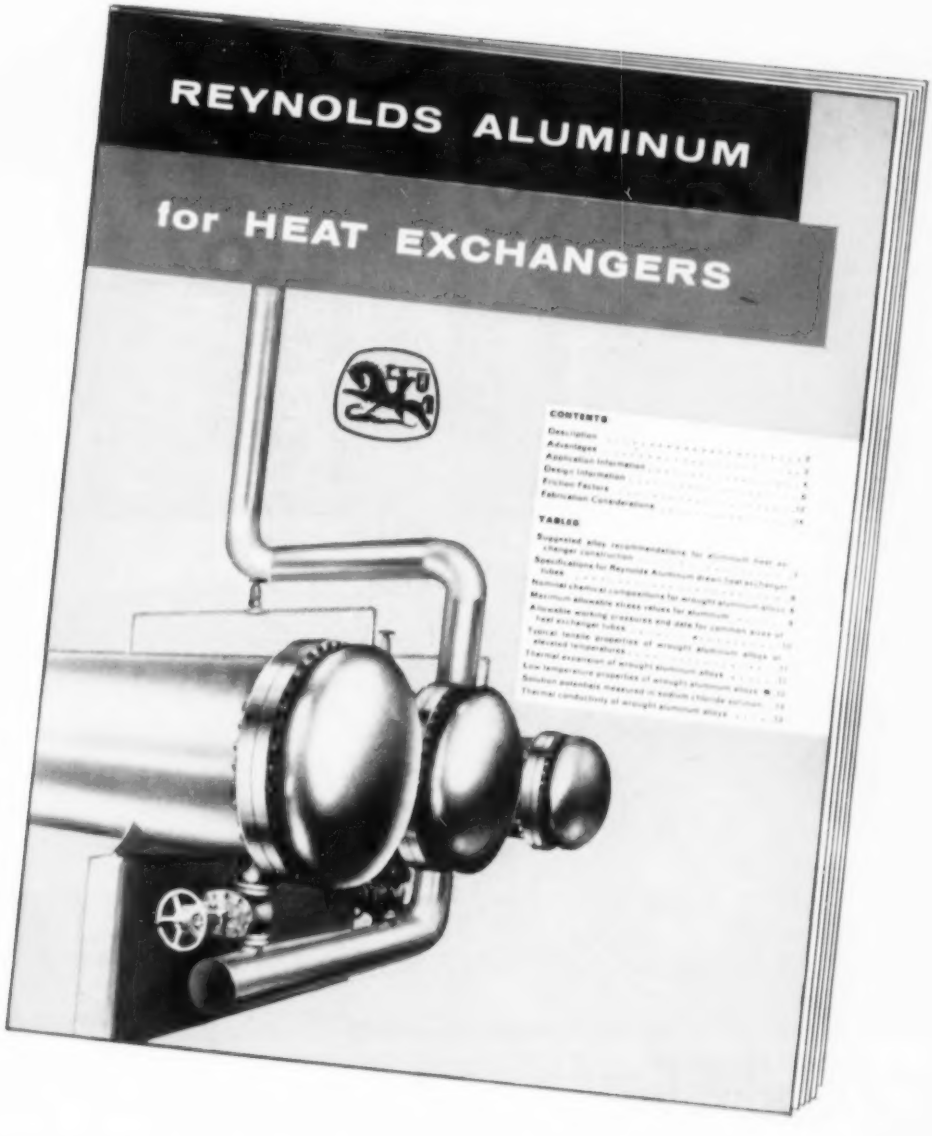
Two important advantages of aluminum make it the natural choice for heat exchanger tubing for most applications. The charts below illustrate cost savings and length of life that aluminum offers. In addition, aluminum heat exchanger tubing provides improved heat transfer rates due to its exceptional non-fouling characteristics.

To help you put these advantages to work in your heat exchanger operations, Reynolds engineers have prepared a sixteen page brochure titled "Reynolds Aluminum for Heat Exchangers." This booklet covers detailed engineering information necessary to the best use of aluminum in many types of heat transfer. The brochure, dealing with some of the varied application possibilities, is reproduced on the adjoining page. Copies of the brochure may be obtained by using the coupon in the lower right hand corner of this advertisement.

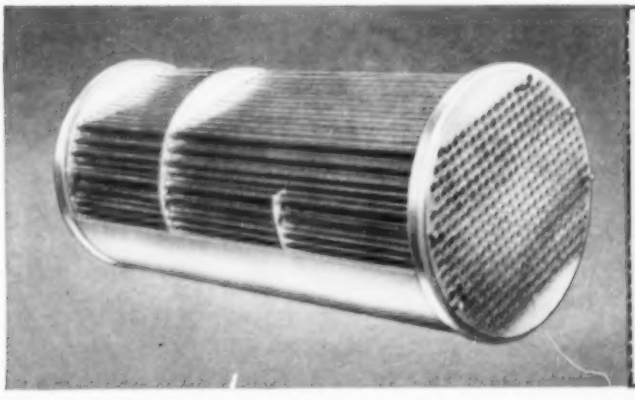
See Reynolds New Program "Frontier"—Sundays on NBC-TV.

REYNOLDS





ALUMINUM



REYNOLDS METALS COMPANY
P.O. Box 1800—CS
Louisville 1, Kentucky

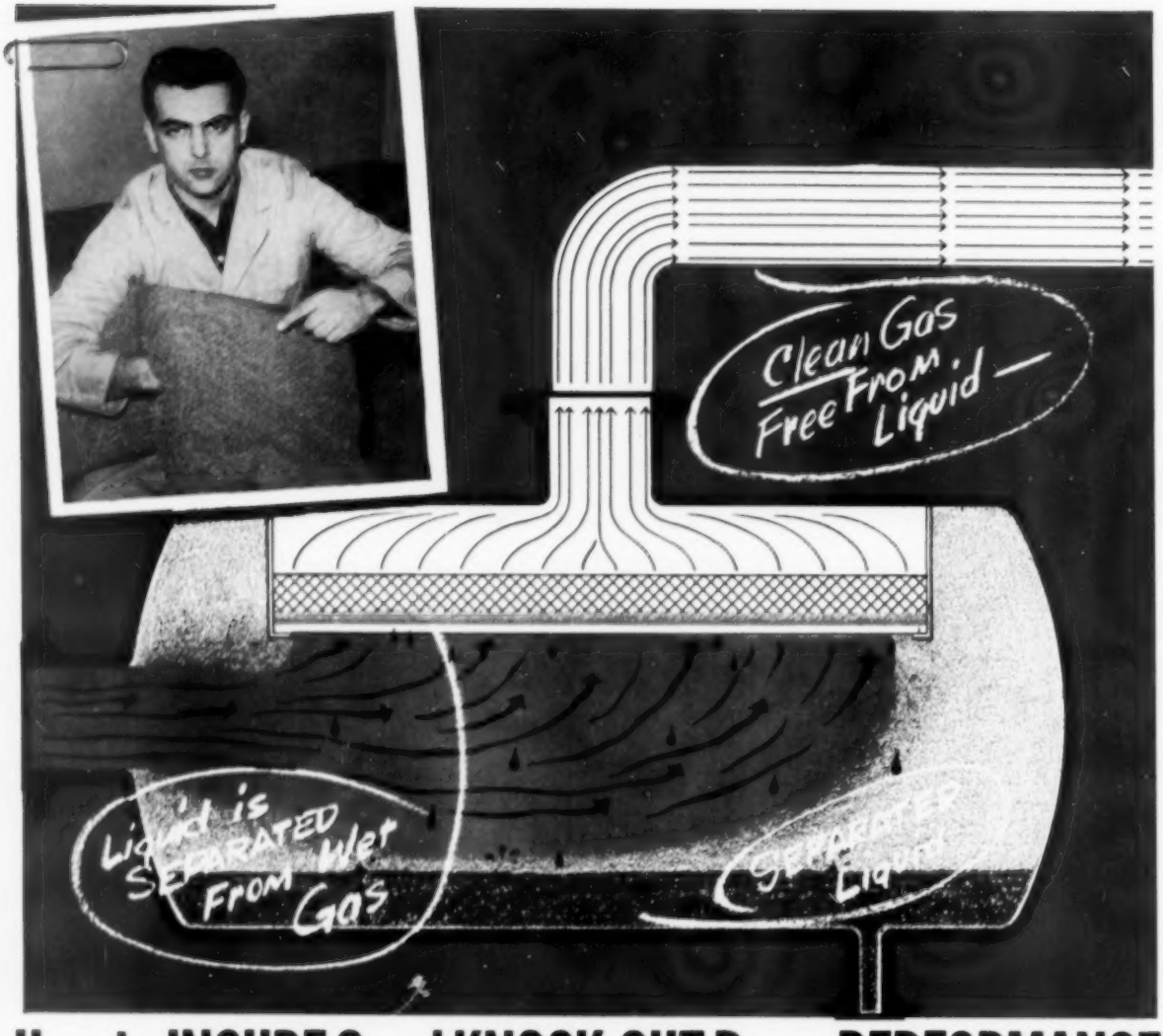
Please send me your 16-page brochure entitled "Reynolds Aluminum for Heat Exchangers"

Name_____

Company_____ Title_____

Street Address_____

City_____ Zone____ State_____



How to INSURE Good KNOCK-OUT Drum PERFORMANCE

The only positive way to insure good performance in Knock-Out drums is to provide a positive barrier to entrained liquid flow which at the same time is practically non-restricting to gas flow.
This dual requirement is inherent in YORKMESH DEMISTERS where the high percentage of voids permits unobstructed gas flow and the extensive surface area effectively separates out the entrained liquid.
The practical result is high separation efficiency at low pressure drop.
For existing or new equipment why not send operating data, and let York Engineers take the responsibility for improved performance.
We will recommend and select the best style Demister from the many available, which includes the hi-thruput Herringbone style.

Similar improvements in process efficiency are effected by the clean separation of vapor from liquid in:

Vacuum Towers • Flash Tanks
Distillation Equipment • Evaporators
Absorbers • Scrubbers • Steam Drums

Write for Bulletin 17 and a complete list of the many case histories available from our technical library.

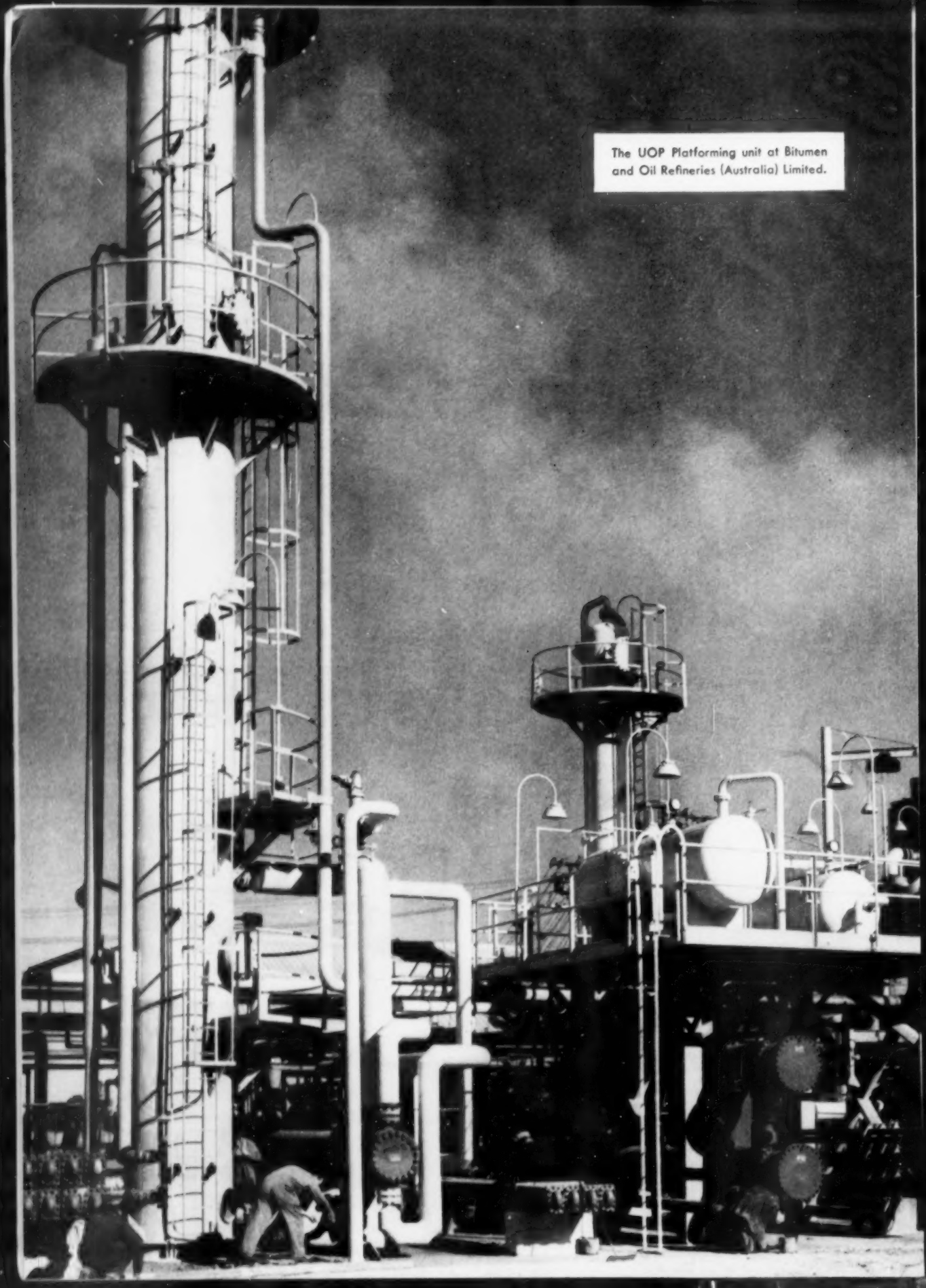
YORK

OTTO H. YORK COMPANY, INC.
6 Central Avenue, West Orange, N. J.

Specialists in FLUIDS SEPARATION / ENGINEERS and MANUFACTURERS

In water conditioning... one grows taller than the rest!

W. H. & L. D. BETZ, Philadelphia, Pa.



The UOP Platforming unit at Bitumen and Oil Refineries (Australia) Limited.

Australian Refiner Reports on 3 Years Operation of UOP Platforming Unit

By E. R. Griffin
General Manager
Bitumen and Oil Refineries (Australia) Limited
Matraville, New South Wales

BORAL has the distinction of being the first refiner outside the American continent to install a UOP Platforming unit, and in more than three years it has operated absolutely trouble-free. Since it went on stream in July, 1952, it has been shut down only for inspections and for cleaning or changing catalyst. In our opinion, this remarkable record was not only achieved because of careful operating control, but reflects, as well, the sound processing techniques of operation provided through the application of UOP fundamental basic research and a well designed and engineered process.

E. R. Griffin

The unit at our refinery set a world record for catalyst life, the first charge having lasted for nearly two years. It was dumped on July 1, 1954, having processed 253 barrels of charge per pound of catalyst. A Platformate yield of 94.1 per cent, based on reactor charge, was realized over the entire run and at the time of dumping, it was still making the 72 octane (motor method) standard grade of motor fuel called for in the local market with the addition of only 1.2 cc. TEL. Making such an octane proved to be an easy job for the Platformer even though Middle East naphthas, processed in the unit, generally are among the least desirable charge stocks for catalytic reforming operations.

Now, the standard grade motor fuel has been increased to 79-81 (research), and a premium grade of 90 research octane has been introduced, both of which are being produced by the Platforming unit without difficulty.

The decision to install the Platforming unit, which had an original design capacity of 1,500 barrels per stream day, came after an exhaustive investigation in which it was determined that this process would give us the flexibility we needed in the selection of a charge stock. Our refinery in Sydney then consisted of a 5,000 B/SD two-stage distillation unit and an asphalt converter unit. A synthetic crude oil, to which was added a small quantity of cracked gasoline, was obtained from the Persian Gulf area for processing into Diesel oil, fuel oil and various grades of asphalt. The gasoline was distilled and sweetened for sale in the local market.

Economics dictated that the processing of whole crude would be more profitable than running synthetic crude because low octane straight run gasoline obtained from whole crude could be upgraded in octane by catalytic reforming with much higher yields than could be obtained by conventional thermal reforming, which was expensive and unsuitable for our requirements.

Having decided to install Platforming, we asked UOP to send an engineer to Australia to assist us in planning for the construction of the unit. Engineering, detailed drafting and purchasing of items not readily obtainable in our country for erection of the Platformer were handled by UOP, which licensed the process. Refinery personnel built the unit.

We decided in 1954 to expand our refining facilities and improve the quality of our other petroleum products. After discussions with UOP on the best course to follow, we concluded that the Unifining process would be most adaptable to our needs. Universal was requested to prepare the engineering and detailed drafting and to purchase hard-to-get items as well as to prepare the design and engineering for revamping the Platformer to increase its capacity to 2,500 B/SD, and to prepare the process designs for a 10,000 B/SD topping plant.

Exhaustive work in Universal's laboratories resulted in the design of a "tailor-made" Unifining unit which processes a combination of Diesel fuel and aromatic light oil produced from an oil gas plant located in Sydney. The Unifining unit has made BORAL one of the first refiners in the world to offer Diesel fuel purified by the use of hydrogen.

In conclusion, we would like to say that our association with UOP not only has enabled us to keep abreast of the most modern refining techniques, but it has made available to us technical "know-how" which has proved invaluable.

DOWN UNDER
BORAL USES UOP
PLATFORMING TO PROVIDE
AUSTRALIAN MOTORISTS
WITH HIGH QUALITY
MOTOR FUEL

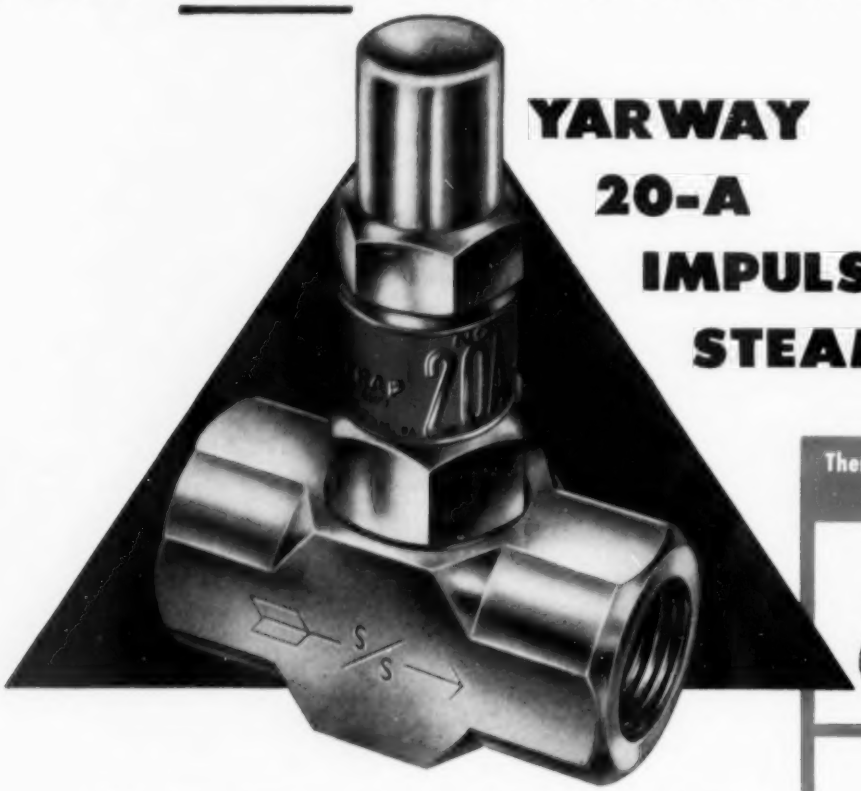
designed, engineered and licensed by

UNIVERSAL
OIL PRODUCTS
COMPANY

30 ALGONQUIN ROAD,
DES PLAINES, ILL., U.S.A.

Forty Years Of Leadership
In Petroleum Refining Technology

THE RIGHT STEAM TRAP FOR LIGHT CONDENSATE LOADS



YARWAY 20-A IMPULSE STEAM TRAP

● Successful companion to the standard Series 60 YARWAY Impulse Steam Trap, the ½" No. 20-A is right and recommended for *light load* applications in:

REFINERIES, CHEMICAL AND PROCESSING PLANTS on steam tracer lines, meter boxes, steam mains, separators, small dryers, pipe coils, small unit heaters, etc.

POWER PLANTS on headers, fuel oil preheaters, compressed air lines, small steam jacketed fire pumps, etc.

HOSPITALS, SCHOOLS, HOTELS AND INSTITUTIONS on autoclaves, sterilizers, steam tables, washers, small pressure cookers, steam mains, etc.

LAUNDRIES on small presses, puff irons, sock forms, drying cabinets, starch cookers, steam mains, etc.

The 20-A has all the YARWAY Impulse Trap features such as small size, stainless steel body and working parts, low cost, non-freezing—and immediate availability through 270 local Industrial Distributors.

Write for Bulletin T-1739-X.

YARNALL-WARING COMPANY
153 Mermaid Avenue, Philadelphia 18, Pa.

There's a Yarway Impulse Trap for every trapping need

SERIES 60 AND 120
For all *normal* trap requirements, pressures to 400 and 600 psi.

½" No. 20-A
For *light loads* on tracer lines, steam mains, small presses, etc.

SERIES 40
For *heavy loads* requiring extra high capacity steam traps.

INTEGRAL-STRAINER HIGH PRESSURE TRAP

For *high pressures, high temperatures.* (Flanged or welding connections.)

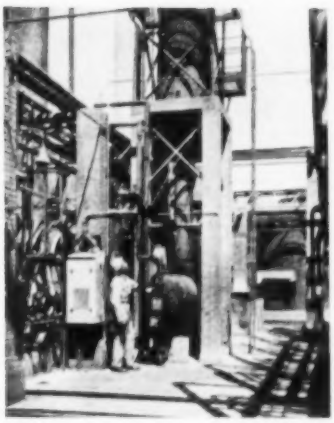
YARWAY IMPULSE® STEAM TRAP

OVER 1,000,000 YARWAY IMPULSE STEAM TRAPS USED

(To obtain more data on advertised products see page 182)

Monel-lined HF valve **works when needed**

Monel-protected HF alkylation plant runs safely on non-stop schedule



Monel-lined HF regenerator resists HF concentrations up to 92% at temperatures to 280°F and pressures to 80 psi.

When to consider Monel for HF alkylation equipment. Monel nickel-copper alloy provides useful resistance to HF in all concentrations and (in unaerated solutions) up to 250°F. It is used with the anhydrous acid at temperatures up to 1100°F. Monel is comparatively unaffected by high stream velocities. Its strength and wear resistance is high.

INCO Nickel Alloys

Imagine the fire-works if a high octane plant *couldn't* be shut down!

When Continental Oil's Ponca City refinery was constructed during World War II, HF alkylation was new. But gasoline was desperately needed. So even before materials research could be completed, plants had to be built.

Valves were the trouble-makers. Corrosion plus internal stresses cracked them. And corrosion product build-up on critical valving surfaces interfered with operation.

Continental solved this fast. With Monel* nickel-copper alloy welded overlays. (Later they put in solid Monel alloy valves.)

Silver lining goes next

The next thing to go was the silver lining of the acid regenerator. Here sulfur-laden 85-87% acid at 280°F. and 80 psi is present. In 1945, Monel alloy was tried. That did it. Now, tower lining and reboilers, condenser and adjacent piping are all Monel. So are unique liquid level probes within the reboilers. So are relief valves, pump seals, bolts, and acid-propane fractionating tower trays.

Now operates non-stop

Today, Continental runs its alkylation units as long as twelve months at a time. Without a halt. Safely. The company estimates Monel saves from 15 to 25% over former operating costs.

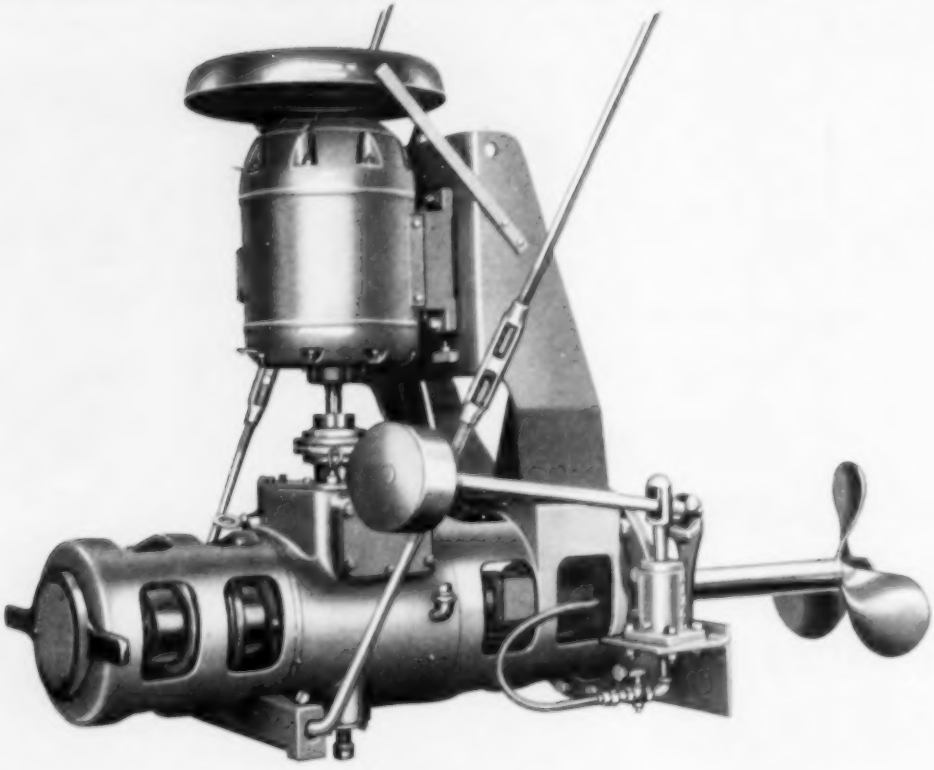
Are you having difficulties traceable to HF corrosion? Put the problem up to Inco's Corrosion Engineering Section. You'll get practical help.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

*Registered trademark

Monel... *for minimum maintenance*

(To obtain more data on advertised products see page 182)



This is the mixer **you** *helped design*

You wanted a big-tank mixer that would mix fluids fast—to complete uniformity. But that wasn't nearly enough.

You wanted a mixer you could *forget.* A mixer that would run year in, year out, with the barest routine attention.

You first told us about the need for a shaft bearing that wouldn't have to run submerged in the tank liquid.

That's when we put *ball bearings* in LIGHTNIN Mixers—and moved the bearings back *out* of the tank, away from grit and trouble.

You didn't want to be bothered aligning the mixer when you put it on the tank. So we housed the LIGHTNIN in three rigid castings, joined with concentric rabbet fit that can *never* get out of line, no matter what.

You wanted the gears protected from unusual shock loads—as might happen if the propeller whacked a ladder or other obstruction in the tank. We found the answer for you—in *hollow-quill drive* that isolates the gears from the shaft, protects your investment with a flexible coupling between shaft and gearing.

You wanted to repack the mixer stuffing box quickly—without having to figure out where to put 180,000 barrels of product while repacking. We developed the LIGHTNIN shutoff device that pulls the shaft back like a valve stem, sealing the tank so you don't lose even a pint of product. And we put *handles* on the shutoff because your maintenance men like it that way—out in the open, easy to get at.

But then you got to wondering about the stuffing box itself. Would a rotary mechanical seal do the job better? What about *replacing* the seal, if it ever wore out?

This time, your quest for something a little better *really* paid off. Now you can get a LIGHTNIN Mixer that runs for years *without repacking or adjustment.* No stuffing box. No leakage around the tank. And should the LIGHTNIN Seal ever wear out, you can replace it in *minutes.* No dismantling. No unhitching the mixer from the tank. *No need for special skill.* It's saving oil companies thousands of dollars a year in upkeep!

Thanks to your telling us what you like—and don't like—in a mixer, hundreds of LIGHTNINs have been in service for more than 25 years. More than ever, today's LIGHTNINs meet your needs realistically, in every respect. More reasons than ever before to put LIGHTNINs on *your* big tanks.

For quick, knowing help on fluid mixing, call your LIGHTNIN representative. (He's in Refinery Catalog.) Or write us.

Lightnin® Mixers

MIXCO fluid mixing specialists

CUT MIXER MAINTENANCE 60% with this new LIGHTNIN cartridge-type rotary seal—optional with LIGHTNIN Mixers. It runs for years without adjustment—and slides off the shaft for fast, easy replacement if ever necessary.

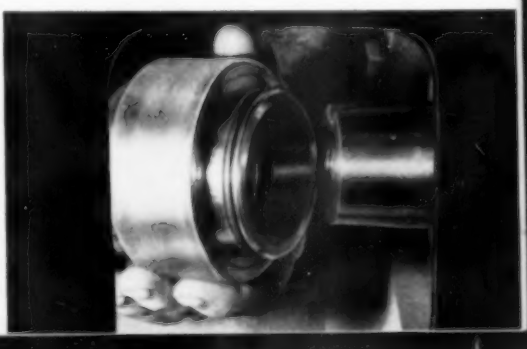
FOR LATEST MIXING INFORMATION and full description of LIGHTNIN Mixers, send for these helpful bulletins:

- ☐ B-102 Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP
- ☐ B-103 Top entering; propeller types: ¼ to 3 HP
- ☐ B-108 Portable: ⅛ to 3 HP
- ☐ B-104 Side entering: 1 to 25 HP
- ☐ B-112 Laboratory and small-batch production types
- ☐ B-110 Condensed catalog showing all types
- ☐ B-111 Quick-change rotary mechanical seals for pressure and vacuum mixing
- ☐ B-107 Data sheet for figuring mixer requirements

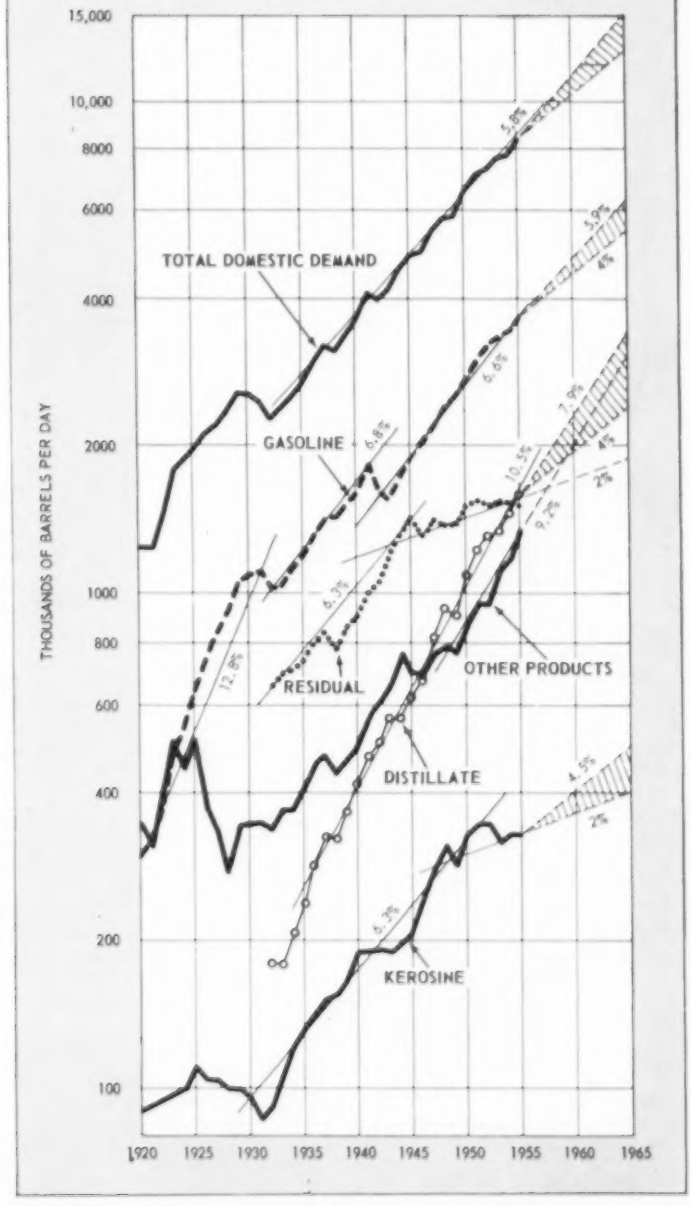
Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc. 131-c Mt. Read Blvd., Rochester 11, N. Y.

In Canada: Greey Mixing Equipment, Ltd., Toronto 10, Ont.



To Meet these Demands . . . . . in 1965 . . .



RATE OF GROWTH OF DEMAND for the main petroleum products in the U. S. since 1920, with projections to 1965

U.S. Refiners Will Need 50% More Capacity

OVER the next 10 years, U. S. refiners and gas liquid processors will face these changing supply-demand conditions:

1—Domestic demand for petroleum products will reach 12.8-million b/d by 1965, an increase of 52.7% from 1955.

2—Refining capacity in the U. S. will be expanded 50%—to around 12.6-million b/d—to provide facilities for this large increase in demand. This expansion, plus additional gas liquid recovery facilities, will require oil companies to invest around $11,275,000,000 in new and replacement plant facilities in the U. S.

3—Product ratios will shift somewhat. Biggest gain will be in the prod-

You'll Split the Barrel Differently—

Shifts in U. S. Product Demand—1955-1956

(Thousands of bbls. per day)

Product	1955 Demand	%	1960 Demand	%	1965 Demand	%
Gasoline	3,630	43	4,425	42	5,375	41
Kerosine	320	4	350	3	400	3
Distillate	1,580	19	1,925	19	2,350	18
Residual	1,510	18	1,675	16	1,840	14
Other*	1,340	16	2,075	20	3,175	24
TOTAL**	8,380	100	10,450	100	13,140	100

* Includes jet fuel, LPG, asphalt, road oil, petrochemicals, and others.

** Estimated total demand for 1960 and 1965 calculated from projected demand for individual products. These totals are somewhat higher than "plausible" demand predicted on the basis of 20 different estimates.

Our Supplies of Crude—

Free World Crude Oil Production—1955-1965

(Thousands of bbls. per day)

	1955	1960	1965
United States	7,495	8,870	9,870
Free Foreign:			
Western Hemisphere:			
Canada	345	650	1,000
Venezuela	2,150	2,700	3,000
Mexico	250	400	550
Other Western Hemisphere	335	450	700
Total Western Hemisphere	3,080	4,200	5,250
Eastern Hemisphere:			
Middle East	3,240	4,830	8,280
Far East	365	500	650
Other Eastern Hemisphere	145	250	500
Total Eastern Hemisphere	3,750	5,580	9,430
Total, Free Foreign	6,830	9,780	14,680
Total, Free World	14,325	18,650	24,550

ucts which at present have relatively small volumes—jet fuels, LPG, petrochemicals, asphalt, and some others. As a group, they will take 24% of refinery output in 1965; today it is 16%. Other products will show drops.

4—Imports will be up sharply to meet U. S. refiners 1965 processing needs About 3.2-million b/d of crude oil and residual fuel will have to be imported, to supplement 8.7-million b/d of domestic production and 1.17-million b/d of gas liquids.

These conclusions stem from an analysis by PETROLEUM PROCESSING's editors of a comprehensive report on the future growth and financial requirements of the Free World petroleum industry which has been made by the Petroleum Department of Chase Manhattan Bank, New York.

"The expansion of the Free World petroleum industry in the coming decade will call for substantially increased supplies of oil, important shifts in the pattern of supply, and very large amounts of new capital to provide the facilities for the expected expansion," states the report. Its authors are Dr. Joseph E. Pogue, petroleum consultant for the bank, and Kenneth E. Hill, vice president of its Petroleum Department.

The bank's survey did not include the areas behind the Iron Curtain. Also, no allowance was made for the development of nuclear energy in the coming 10 years, because it is believed that energy from this source is within the margin of error in the demand projections.

A detailed discussion of the four conclusions outlined above follows. Much of the information was taken from a paper Dr. Pogue and Mr. Hill prepared for presentation at the annual meeting of the Petroleum Branch of the American Institute of Mining, Metallurgical and Petroleum Engineers, Feb. 21. Additional details, however, were obtained directly from the authors.

1—Domestic Demand

Total domestic product demand of 12.8-million b/d set for 1965 is termed a "plausible" demand, and was selected from 20 different forecasts either made by the Chase bank investigators or included in their study. It represents an annual growth rate of 4.3% compounded from 1955 to 1965, compared with a 5.8% annual growth rate compounded in the consumption of oil in the U.S. for the past 23 years. In addition to a domestic demand of 12.8-million b/d, it is estimated that exports of petroleum products from the U.S. will take another 200,000 b/d.

Looking at the halfway point, domestic demand in 1960 was forecast at 10.3-million b/d, plus 275,000 b/d for export.

In the free world outside the U.S. product demand by 1965 is forecast at 12-million b/d, almost matching that of the U.S. then. Such a demand will represent a gain of 103.4% from the estimated demand of 5.9-million b/d in 1955. Demand in 1960 is forecast at 8.4-million b/d.

For the past 13 years, the rate of increase in foreign demand has approximated 11% per year compounded. The plotting of scattered information seemed to substantiate a probable growth factor during the next 10 years of 7% or better. The data available was not deemed adequate for computing future foreign demand by individual products.

Taking both U.S. and foreign demand together, total free world demand by 1965 is foreseen as 24.8-million b/d, an increase of 73.7% from 14.28-million b/d in 1955. Demand by 1960 is estimated at 18.7-million b/d.

2—Refining Capacity

It was estimated by the Chase Manhattan investigators that total operable refining capacity in the U.S. at the end of 1955 was 8.4-million b/d. This capacity will have to be expanded to around 12.6-million b/d by 1965, they predict, to allow refineries to provide their 11-million b/d share of the total product demand of 13-million b/d then. (The balance will come from natural gas liquids and imports of residual oil.)

This expansion will require refiners and natural gas liquid processors to invest $11,275,000,000 in new plants and replacement of obsolete facilities, $4,975,000,000 during the 1955-60 period and $6,300,000,000 during 1960-65. This required investment over the coming 10 years will be larger than the total current investment in processing facilities, which is estimated at $7-billion. Total invest-

ment in refining by 1965 will be around $18,275,000,000.

The Chase Manhattan authorities estimate that the capital investment which the entire U.S. petroleum industry will have to make over the next 10 years to meet 1965 demand will be close to $75-billion.

The required investment in petroleum facilities in the Free Foreign world in the next 10 years is estimated at $41,450,000,000. Of this total, refining facilities will take $8,800,000,000. In volume of facilities, the expansion in the Free Foreign world will be larger than in the U.S. The fact that different types of refineries will be built, with lower cost per barrel of charge capacity, explains the lower over-all investment in refining there as compared with the U.S.

The total new capital investment in the petroleum industry in the Free World from 1955-65, the Chase Manhattan Bank authorities estimate, will be $115-billion. Of this amount, about $20-billion will be expended in refining, over $66.5-billion in exploration and production, and $28.3-billion in transportation and marketing.

Oil Balance Sheet—

Shifts in U. S. Product Demand—1955-1965

(Thousands of bbls. per day)

United States:	1955	1960	1965
Product Demand	8,380	10,300	12,800
Exports	365	275	200
Total Demand	8,745	10,575	13,000
Crude Production	6,775	7,860	8,700
Gas Liquids Production	720	1,010	1,170
Total Production	7,495	8,870	9,870
Inventory change	−17	+75	+75
Excess of Requirements over U. S. Production	1,233	1,780	3,205
Free Foreign:			
Product Demand	5,900	8,400	12,000
Exports	1,233	1,780	3,205
Total Demand	7,133	10,180	15,205
Inventory Change	+162	+75	+75
Imports from U. S.	365	275	200
Other Sources*	100	200	400
Required Production to Meet Demand	6,830	9,780	14,680

* Includes production of synthetics and natural gas liquids, and imports from Soviet-controlled countries.

3—Product Ratios

One of the forecasting techniques used to estimate future demand was to estimate demand for individual products separately, based on previous experience and probably future rate of growth. Total U.S. demand thus arrived at was 10.45-million b/d by 1960 and 13.14-million b/d by 1965. An accompanying table shows the demand for individual products in 1960 and 1965 which makes up these totals. Also shown in the table is the percentage of total demand for each individual product for these years.

The principal change in the relationship of individual product demand to the total foreseen for 1965 is a large growth in the requirements for what are shown as "others." This group of currently relatively small volume products includes principally jet fuels, but also LPG, petrochemicals, asphalt, road oils, and some miscellaneous items. The requirements of this group will be 3,175,000 b/d by 1965, 24% of the refiner's total output. Its volume will be more than double the 1955 total of 1,340,000 b/d for this group of products, which was 16% of total requirements.

The principal contributors to the volume growth of this group of products will be jet fuels and LPG. The consumption of jet fuel by 1965 will be more than double today's volume and may reach 500,000 b/d, it is estimated. The volume of LPG marketed today (including liquefied refinery gases) is around 400,000 b/d. Continuation of its growth since World War II would bring the 1965 total to around 1-million b/d.

The relatively lower yields for gasoline and distillate fuels as shown in the table and compared with 1955, reflect mainly the coming use of some portion of these cuts from the refiner's barrel of crude to make up the volume of jet fuel which will be required by 1965. The lower yield of residual fuel anticipated by 1965 will be a logical continuation of the present trend in refining operations to convert more of this material into more profitable products.

U. S. Refiners Will Invest Almost $20-million to Meet Demand 1965

A modification downward in the growth rate for motor gasoline and distillate fuels over the next 10 years is foreseen by the Chase Manhattan economists. This modified trend will materially affect total demand for these products by 1965. Total gasoline demand by that date is forecast at 5,375,000 b/d. This demand is based on a growth rate of only 4% per year, compared with a growth of 5.9% per year for the past five years.

The modified trend in the rate of growth of distillate fuels use which is forecast brings the 1965 total demand to 2,350,000 b/d, based on an annual growth rate of 4%. Growth in demand for distillates over the past five years was at the rate of 7.9%.

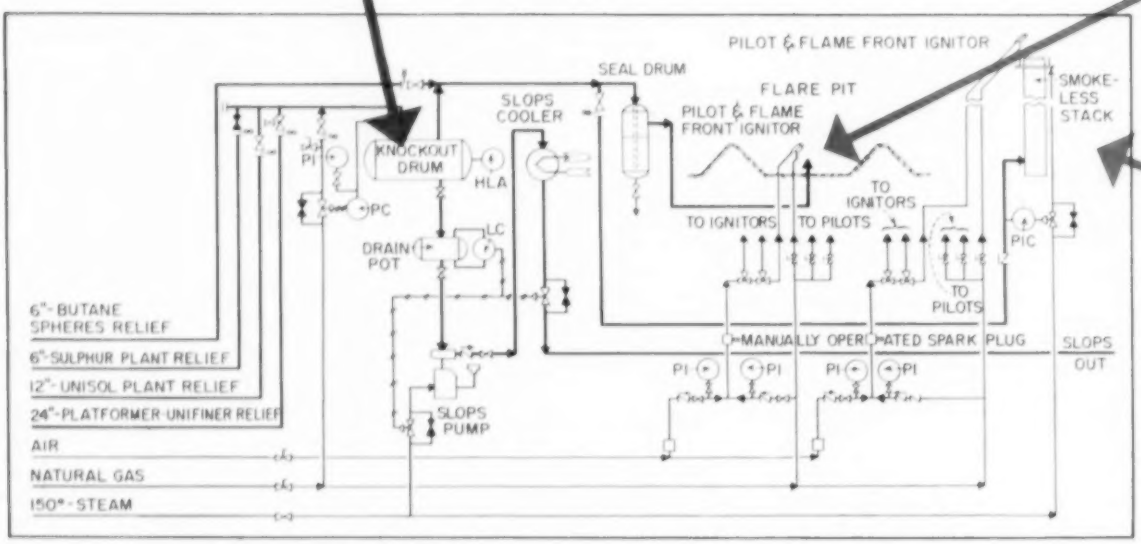
4—Imports

By 1965, the Chase Manhattan survey brings out, U.S. refiners and manufacturers of finished products from gas liquids will be called on to supply 13-million b/d of finished products. By that time, it is believed, 85% of total demand will be supplied by refineries, or around 11-million b/d. If the supply of gas liquids reaches 1-million b/d by that time, as anticipated, another 1-million b/d of residual fuel oil may have to be imported to supply total demand.

U.S. crude oil production by 1965 is estimated at 8.7-million b/d. Something over 2-million b/d of crude oil would then be required to supply charge stock for the indicated refinery output of 11-million b/d.

The Free Foreign World, the study shows, by 1965 will be producing crude oil at the rate of 14.68-million b/d. Its product demand is set at 12-million b/d, and exports of both crude and products (the latter mostly residual fuel oil) at 3,205,000 b/d. Imports of 200,000 b/d of products from the U.S., and production of 400,000 b/d of natural gas liquids and synthetic are included in the Free World supplies. A summary of the U.S. and Free World supply and demand picture for 1955, 1960 and 1965 is shown in the accompanying "Free World's Oil Balance Sheet."

1—HEART OF THE SYSTEM is the knockout drum and water seal



FOUR AREAS SEND EXCESS GASES to the relief and blowdown facilities at Union Oil

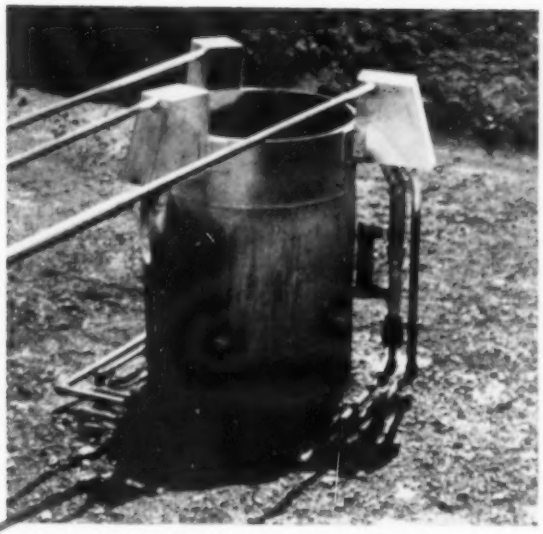
Here's a Workable, Smokeless

Designed for emergency relief and blowdown from one group of new process units at Union Oil Co. of California's Oleum refinery, this system has been operating very satisfactorily for over a year.

The description of this system was written by the two project men who handled it. Mr. Hannaman acted as project manager and resident engineer for Union's mfg. dept., head office engrg. and construction division. Mr. Etingen was project engineer on design and installation for the contractor, Bechtel Corp.

By J. R. HANNAMAN and A. J. ETINGEN

The problem of disposal of excess gas and hydrocarbon liquids beyond the normal capacity of recovery facilities has generally been met by burning these materials in waste pits or flares. Only a decade or so ago these flare pits were considered the "dump" of the refinery. However, because many stringent laws, ordinances and regulations were enacted throughout the country by state, county and city to reduce the air pollution by control of smoke emission, more thought has been given to the design of flare pits and stacks with emphasis on smoke elimination.



2—FLARE PIT, showing flame front ignitors

3—STEAM BUT NO SMOKE flows from the Oleum flare

Flare System

A modern relief and blowdown flare system has been recently installed at the Oleum Refinery of Union Oil Co. of California. This refinery is located in Contra Costa County, on the eastern shore of the Carquinez Straits, north of the San Francisco Bay.

The term "relief and blowdown facilities" is used here to describe a complete relief and blowdown system which includes: a smokeless flare stack, a flare pit, knockout drums, a slops pumpout system, seal drum, and all the instrumentation and alarm systems suporting this equipment.

These facilities were designed to serve a group of newly constructed plants. The units served are a 14,000 b/d Platformer-Unifiner, and Unisol and Sulfur plants. These plants are located in a newly developed area on Tormey Hill east of U.S. Highway 40 at an elevation of 110 ft. above sea level. The nearest existing plant in the refinery is 1,500 ft. away.

It was first considered that a system incorporating the entire process area on Tormey Hill, including the existing plants, should be designed, but the pressure drop in the main headers from the existing plants proved to be too great, because of the great distance between the existing plants and the new installation. After this idea was abandoned, it was decided to design a relief and blowdown system to serve only the new plants, consisting of a short smokeless stack and a ground flare pit.

After a considerable study, this equipment was located at a minimum distance of 400 ft. from any operating plant or storage tank. The elevation of the knockout drum and associated equipment was established as 70 ft. (the plant's elevation being 110 ft.) and the elevation of the stack and flare pit as 97 ft. and 89 ft., respectively.

Flow Description

The system is shown schematically in the diagram at the left. All relief headers from the process units combine into a common 24-in. header which deposits the hydrocarbon gases and liquids into a 10 x 30 ft. knockout drum. The relief line from the butane storage spheres bypasses the knockout drum. Liquids which accumulate in the drum are pumped from the drain pot through a slops cooler to a 15,000-bbl. floating roof tank.

The hydrocarbon gases can leave the knockout drum in two ways. Blows smaller than an equivalent flow of 60,000 lbs./hr of propane flow through a 10-in. line to the smokeless flare stack and are ignited by constantly burning pilots at the tip of the stack. Steam is proportioned to the stack for smokeless burning of the hydrocarbon gases through a control valve set by a pressure indicating controller which is actuated by back pressure of the gases to the stack. When the blow is of such magnitude that the back pressure on the stack line exceeds 48 in. of water, the water seal blows and the gases are dumped to the flare pit through a 30-in. line where they are ignited by constant burning pilots on the outlet of the pit pipe. When dumped to the pit, hydrocarbons will burn with smoke, as equipment was not provided nor considered necessary at this outlet to permit smokeless burning.

Basic Design Considerations

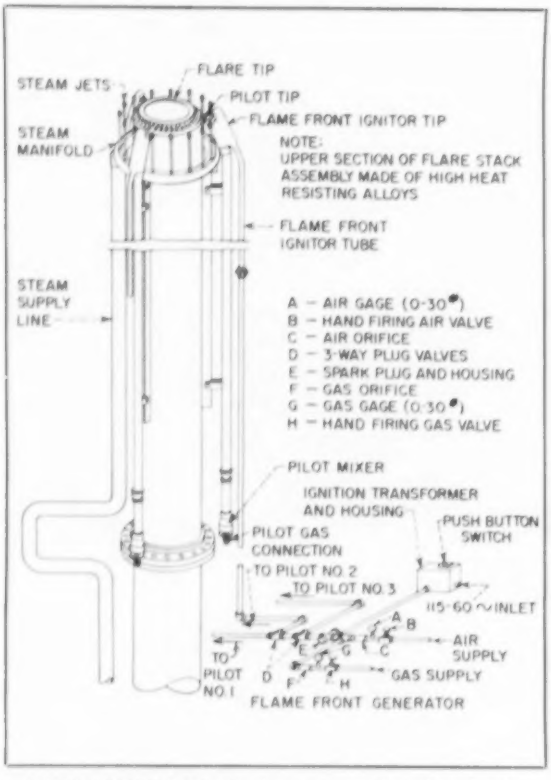
The maximum quantities for which the system was designed are summarized in the table:

Plant	Max. Blow Lbs./hr.	Molecular Wt.	Temp. °F	Pressure Plot Limits
Platformer-Unifiner	425,000	21.4	257	27.0
Unisol Plant	95,990	58	205	12.7
Sulfur Plant	10,730	34	258	10.0
Butane Spheres	14,000	58	40	6.5

These design conditions are based either on fire blowdown load or cooling water failure load, depending on which is controlling for the unit involved.

All effort was made within design of the units to reduce their potential blowdown loads. This was done primarily because of space limitations for safe location of the

■ Smokeless Flare System



SMOKELESS FLARE TIP, showing construction details

ground flare and also because of economics of required header piping size. As an example, the Platformer-Unifiner relief load, which was the controlling design condition for the system, was based on cooling water failure at these units. The units are combined and served by a central cooling tower. Initial calculations indicated that the large relief load resulting from total failure of the entire cooling system precluded safe installation of a ground flare with the real estate available and also would require extremely large headers.

To reduce this requirement, the basin of the cooling tower was divided into two sections with separate water supply and return headers for each section. This minimized the possibility of disrupting the entire cooling water system and cut the design relief load essentially in half to the quantity shown in the table.

Balanced area type relief valves were used wherever feasible within the units to increase available plot limit relief pressure in order to reduce the size of headers to the flare. Headers were sized on the basis of the design gas flow rates not to exceed 80% of sonic velocity.

It was assumed that the smokeless flare stack design capacity, 60,000 lbs/hr of propane, was sufficient to take care of operational irregularities and leaky relief valves. In the event of a heavy relief, the water seal in the seal drum will blow out and the hydrocarbons will burn in the ground flare pit with smoke. Reliefs of this magnitude are rare and are the result of a major emergency. Smoke emission would be inevitable.

The relief line from the butane storage spheres bypasses the knockout drum. This was done to eliminate any possibility of pumping butane into the slops tank, where the butane might flash and expose the tank to excessive pressure. The temperature of the slops was estimated at 300°F. It is reduced to 100°F by pumping the liquid through a shell and tube cooler.

A turbine was selected to drive the slops pump because a failure of electrical power can cause some of the units to blow, requiring the pump. To eliminate any possible accumulation of an explosive mixture within the equipment and piping, the entire system is blanked with natural gas, maintaining a pressure of one inch of water at the knockout drum.

Operational and Alarm Features

The smokeless burner, shown in the drawing, is a John Zink Co. burner of latest design, Type STF-14. This unit is well known in the industry and will be discussed here only briefly, stressing the newly developed features. The stack is 14 in. in diameter by 15 ft. in height. The upper 8 ft. are a high chrome alloy. Smoke is suppressed by 27 steam jets set in an alloy ring manifold. The steam jet tips are set alternately 30° and 45° from the vertical, thus creating two steam cones to reduce back pressure caused by steam entering the stack, and to improve aspiration of air into the flame zone. Steam consumption of the burner, at peak blow, is 12,000 lb/hr (0.2 lbs of steam per lb of gas).

The burner is equipped with a "constant pilot ignitor hood." This hood is hollow and encloses the upper portion of the 2-in. pilot supply line. Weep holes are drilled through the supply line about 10 in. below the pilot to allow a portion of the pilot gas-air mixture to bleed into the annular space between the hood and the line. This gas flowing upward toward the tip burns separately from the pilot to hold the ignition for the pilot flame. The flame front pipe enters at the bottom of the hood to first kindle the bled gas and then the pilot tip roper.

The flame front generator is located about 150 ft from the stack to permit remote ignition during pilot failure. The flare pit also is equipped with three pilots and ignitors. These pilots, too, during failure, can be remotely ignited by a flame front generator.

An alarm system was installed to warn the operators (in the adjacent plants) that a pilot is out in either the flare stock or the flare pit. This system consists of Chromel-Alumel thermocouples installed directly in the flame of the pilots, and connected to a six-point temperature recorder, equipped with an alarm switch.

During failure of one of the pilots the drop of temperature at that pilot is recorded on the temperature recorder, which in turn actuates a switch which turns on both a horn and a red light. By inspection of the chart, the operator identifies the extinguished pilot and re-ignites it with the flame front generator.

The knockout drum is equipped with a high level alarm to warn of any excessive accumulation of liquid in the system. This alarm is relayed to the same horn and red light serving the pilot failure alarm. The operator can readily identify which equipment requires attention since high level in the knockout drum causes sustained operation of the horn and light whereas the pilot alarm is intermittent, signaling only when the recorder is reading the temperature of the extinguished pilot.

In order to obtain a smokeless flame at the flare stack, steam must be injected into the flame zone. The quantity of steam required is proportional to both the rate and

INSTRUMENTATION IS SIMPLE. Temperature recorder at left, with ignitor controls to the right, all under a canopy

composition of the hydrocarbon gases flowing to the stack. To proportion the proper quantity of steam to the flame for each blow is a difficult task because of variation in composition of the relieved gases.

For this reason, the instrumentation to control proportionate quantities of steam is limited to pressure control; that is, the steam flow is controlled by the pressure in the blowdown header to the stack. A pressure controller with a range of 0-20 in. of water was installed actuating a 2½-in., quick-opening, control valve in the steam line. A quick-opening valve was selected because its characteristic flow curve closely resembles the characteristics of the stack discharge. Such a valve also responds with adequate steam for reliefs of small magnitude.

Note that the relief headers from the various plants are valved just before the common 24-in. header discharging into the knockout drum. When one of the units is down, its relief header valve is closed and the blowdown system continues to operate while any necessary maintenance is performed on the isolated line.

These block valves were installed in an upside down position to eliminate the remote possibility of the disc of the valve dropping into the header and blocking it (when the valve is in open position) after corrosion of the tee head connection of the stem and disc. The header to the stack is so valved that the stack can be shut down for repairs and the system will relieve through the flare pit during such a period of repair.

The drain pot just below the knockout drum is an auxiliary knockout drum. It will carry, most of the time, the liquid vapor interface where most of the corrosion will occur. It is so valved that it can easily be removed and readily replaced by a duplicate drum without disrupting the operation of the entire system.

Operation

The relief and blowdown facilities have been in operation since mid-January and although some initial adjustments had to be made, it can be said that operation has been very satisfactory.

Gas rates exceeding the capacity of the smokeless stack have been relieved through system several times causing the water seal to blow and putting the pit into operation in a very satisfactory manner.

In one situation, the blowing relief valve was known and the relief quantity was established as 240,000 lb/hr of material of molecular weight of 18.4. Operation of the system at these rates demonstrated that the pit was located at an adequately safe distance from the tanks and operating units.

One feature of instrumentation in the blowdown system had to be discarded after several days of experimentation. This feature consisted of flow indicators located in each relief header just before the common header to the knockout drum. The purpose of these indicators was to show the operators, during small steady emissions, which header was relieving. The flow indicators were actuated by a Pitot tube in the header. The Pitot tube was the only device applicable because of the very small pressure drop available.

During the start of the system, the Platformer was relieving 5,000,000 cu ft/day of high hydrogen content gas (molecular weight: 7). The flow indicators showed no flow. A draft gage was installed and showed 0.03 inch. Thus in spite of the desirability of this feature, it was discarded.

The relief and blowdown facilities were a part of a project designed and constructed by the Bechtel Corporation, San Francisco, California.

Pay the Right Income Tax

Here's a guide to the tax problems of the engineer

By ELI GERVER
American Inst. of Accountants

ARE YOU paying the right tax? No one wants you to pay more than you should. But every year about this time, when the nation's taxpayers sit down with their accumulation of old bills, check stubs, statements, and the famous Form 1040, permissible deductions are overlooked, tax law changes missed, and more income tax than necessary paid.

For instance, you may not know that illness benefits under certain salary continuation plans are now not taxed for the most part; that a portion of stock dividends, and all interest on state and municipal bonds are also not taxed.

You may not know that you can deduct important expenses incurred in consulting work, certain costs of attending meetings and conventions, and even the cost of your trade magazine subscriptions (such as PETROLEUM PROCESSING).

Let's get down to details and consider some facts:

What Income Is Taxed?

The government does not tax all income. Many people receive income that is "excluded" from taxation. For example, if you are sick or injured and your employer continues paying your salary under a salary continuation plan, the first $100 a week is not taxable. When there is sickness, a 7-day waiting period must pass before this provision is effective. If you are injured, or hospitalized any time during your absence, no waiting period is required. The income tax form provides space on the first page for this exclusion from your income.

If you receive dividends on stock that you own, the first $50 received is not to be taxed. If you and your wife each receive dividends in excess of $50, or own stock jointly, the first $100 will be exempt. On pg. 3 of the return, you list the dividends received and subtract from the total the amount you are entitled to exclude.

Here are some examples:

(1) H receives $40 in dividends. W, his wife, receives none. The $40 is excluded from income.

(2) H receives $70 in dividends on stock he owns separately. W receives none. Even though a joint return is filed, only $50 may be excluded.

(3) H and W own stock jointly and received $110 in dividends. H received in his name $60 in dividends, as well. They may exclude $50 each; on a joint return they may exclude $100.

If you own state or municipal bonds, any interest you may receive is completely exempt and need not be shown on the return at all.

Except for the exclusion of up to $100 per week when you are sick, your entire salary is subject to tax. If you did any private consultation work, the fees you received are also subject to tax. However, you are permitted to deduct certain expenses in order to arrive at what the tax code calls Adjusted Gross Income.

Deductions for Adjusted Income

Expenses incurred in private consultation work are deductible. The best way to handle this would be to complete the separate Schedule C on which you show your income as consultant and any expenses incurred. This schedule is filed as part of the regular return.

Meet the Author

Eli Gerver is assistant to the Director of Taxation at the American Institute of Accountants, in New York City. He is a C.P.A. and a lawyer.

Mr. Gerver holds a degree in business administration from the City College of New York (1947), an LL.B. from New York University's School of Law (1953), and expects a Master of Laws degree from the latter school this June.

A native of New York City, Mr. Gerver lives in the Queens. He is married and the father of two children.

Certain expenses incurred because of your job are also deductible in computing Adjusted Gross Income. You may enter on pg. 1 your salary net of these expenses. Attach a statement to your return giving the details of your salary and the deductions you are claiming. For example, if your job requires you to travel away from home, you can deduct the non-reimbursed travel expenses incurred (but not commutation expense), and that includes meals and lodging.

Do you solicit business for your employer away from the office? Non-reimbursed expenses in connection with this are also deductible in computing Adjusted Gross Income.

Do you receive an expense allowance? If so, this money is to be added to your earnings and the expenses you pay are a deduction for Adjusted Gross Income. If your expenses on the job are not reimbursed and you are not an outside salesman or a traveler, then these may not be deducted for Adjusted Gross Income. Deduction of such expense is discussed below.

Transportation expenses incurred as a result of employment can also be listed as deductions for Adjusted Gross Income, even though you may not be on "travel" status. Clearly an expenditure may fall under several categories. But it may be taken only once.

Using the Standard Deduction

Having computed Adjusted Gross Income, the next step is to see what other deductions you have. It may be to your advantage to ignore them and take the *Standard Deduction*, which is 10% of Adjusted Gross Income, or $1000, whichever is less. Space for the computation is on pg. 2 of the form.

The Standard Deduction is in lieu of *all* deductions *except* deductions for Adjusted Gross Income and personal exemptions. It is important, therefore, to review carefully your expenditures for the year and see what you may have in the way of other deductions. If their total is less than the Standard Deduction, it is to your advantage to use the latter. Remember, either way, you may still

take advantage of your deductions for Adjusted Gross Income.

Other Deductions You Can Claim

Medical expenses: If you paid any doctor, dental, or hospital bills, you may deduct any amount in excess of 3% of your Adjusted Gross Income. You may include in your total of medical expenses (before you take off the 3%) any payments for drugs and medicine in excess of 1% of Adjusted Gross Income. (Needless to say, cosmetics, dentifrices, and similar items should not be included just because they were purchased at a drug store.) The 3% limitation does not apply if you or your wife are over 65. Depending on your exemptions, you can deduct such expenses up to $5000 on a single return, or $10,000 on a joint return. Don't be alarmed at the way these limitations are tossed about—page 2 of the form shows what has to be done clearly and concisely.

Non-reimbursed expenses: As stated above, if you had an expense allowance, you included the allowance in your income and deducted the expenses paid in computing Adjusted Gross Income. Other expenses connected with your employment which are not reimbursed may also be deducted. Subscriptions to trade journals, and other technical periodicals, and dues to professional societies are deductible.

If you are doing graduate study, its cost is not deductible unless your job requires it or your employer requests it. On the other hand, the expense of attending professional conventions is deductible. Included here are registration fees and the cost of transportation, lodgings, meals, etc., as long as they are part of legitimate professional activity.

Should you claim these expenses as a deduction, either because you were not reimbursed or because they came out of your expense allowance, keep in a safe place your bills, receipts, and other memoranda relating to such expense. If your return is examined, you will be asked to furnish proof of your deductions.

Work clothes: If you need special clothing on the job, the cost of its maintenance is deductible. However, the cost of the clothing is not deductible if it is readily adaptable for social or general use in the sense that it replaces other clothing. For example, the cost of special protective clothing for use in field work is deductible.

Exemption for Dependents

After listing all your deductions, you are ready to compute your Taxable Income on pg. 2. This figure is what is left after subtracting your deductions (or the Standard Deduction) from Adjusted Gross Income and subtracting from the result the exemptions for yourself, your wife, and your dependents.

Formerly, it was necessary to furnish more than half the support of any relative you wanted to claim as a dependent. Now, if a group of people supplies more than one-half support to a relative, any member may claim the exemption if the others give written consent, even though he did not contribute more than half. Each year another member can take his turn. The only requirement is that he contribute at least 10% of the support.

In past years parents lost dependency exemptions for any of their children who earned more than $600 in part time or summer jobs. Now, if the child is under 19 or is a full-time student, he may earn as much as he can. As long as the parent supplies more than half the amount required for the support of the child, the exemption is not lost. The child may still file his tax return and take his personal exemption of $600. In effect, there can be a double exemption of $600, once by the parent and once by the child.

Computing Your Tax

As stated above, the amount left after you have subtracted your exemptions and deductions from your income is your Taxable Income. This is the figure on which you base your tax. Rate tables are furnished with the instructions. Be careful in your computation to select the right table. There are separate rate tables for individuals, joint returns, and heads of households.

Dividend Credit

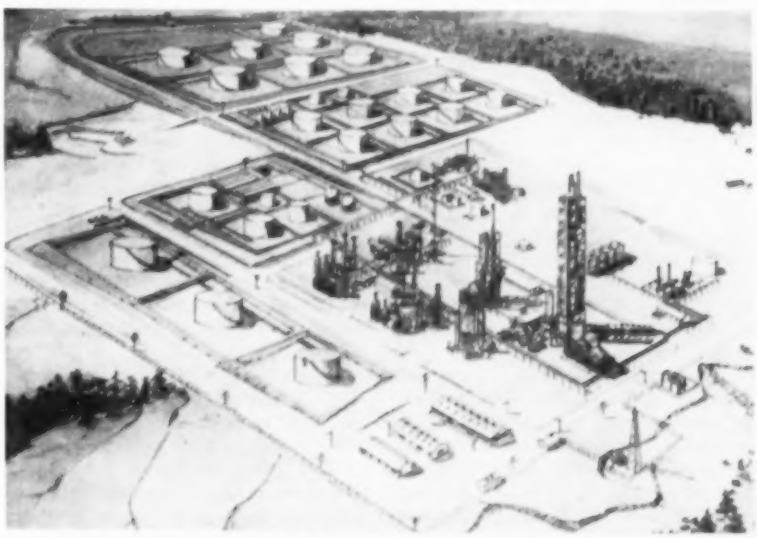
If you received dividends in excess of $50, you get a further tax reduction. You can lower your tax, but not below zero, by 4% of the dividends you included in income. The credit is computed on pg. 4 of the return.

Plan Your Tax Now

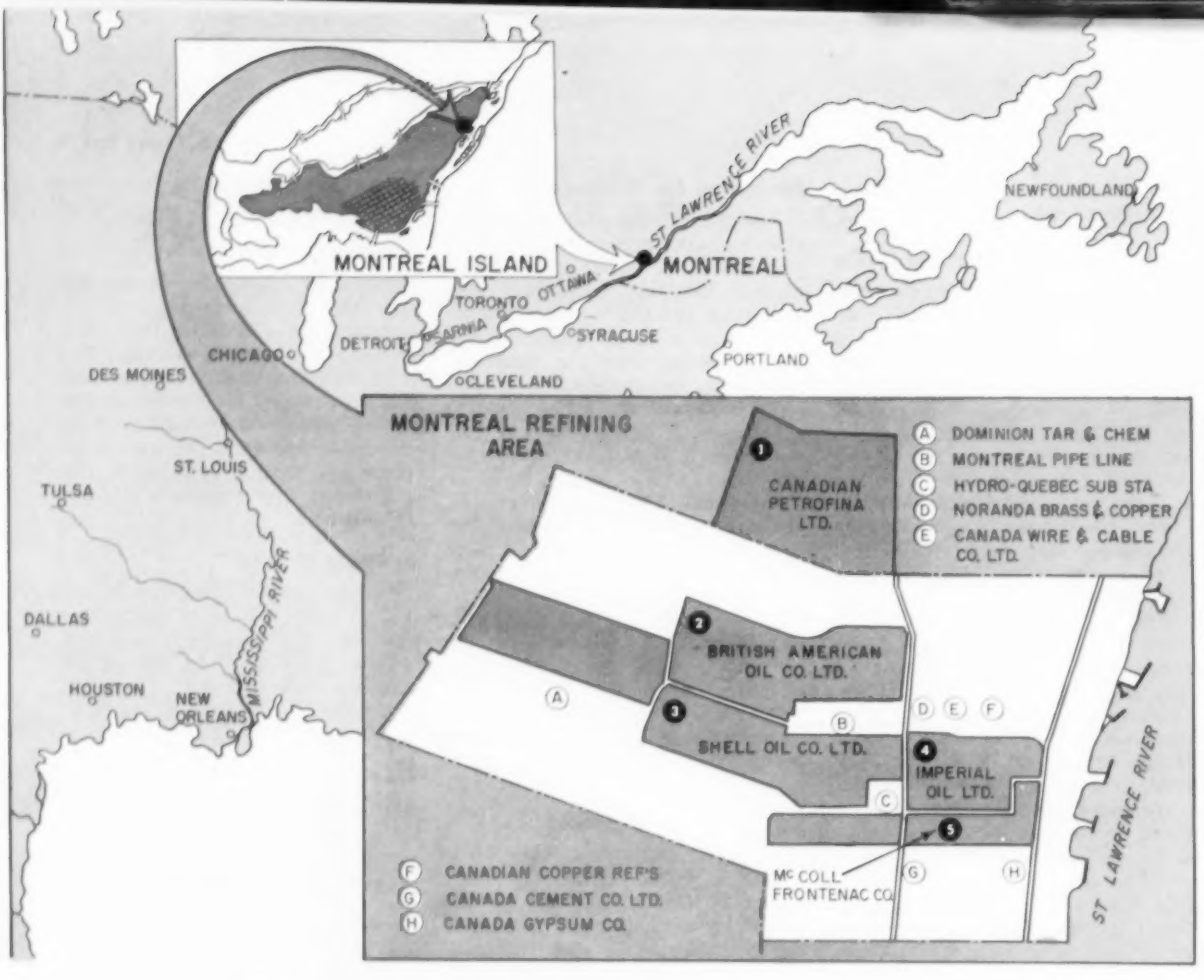
This is hardly the time to plan your tax for 1955. Planning your tax is a year-round job. Now is the time to start on 1956. Keeping adequate records in 1956 may be the key to a lower tax for the year.

Prepare your tax return before the last minute. Deadline work often causes overlooked deductions and payments larger than necessary.

NEWS in VIEWS



NEW REFINERY IN MISSISSIPPI—Pontiac Eastern Corp. will build this $18-million, 12,000 b/d plant near Purvis, in Lamar County. Construction contract is held by Fluor Corp. Estimated completion time is 15 months



MONTREAL

A Major Petroleum Processing Center

IF YOU DOUBT the headline, look at the map. Five refineries next to one another—the densely developed, 2,800 acre site just outside city limits. Together, these plants will be refining 240,000 b/d this year, more than a third of Canada's 1956 total capacity of almost 670,000 b/d.

The refining center's products sold for about $345-million in 1955, more than 10% of Montreal's annual product value of some $3-billion. This sum was the largest single contribution to the local economy.

The summary tables on pp 74, 75 tell who's who and what's what. Industry men coming to Montreal for the API Refining Division's mid-year meeting, May 14-17, should find these tables especially useful. Additional description of each of the area's refineries and petrochemical plants starts on page 76.

What made Montreal a refining center?

In many ways the island is ideally located as a refining area. Here are the factors that shaped the area's development:

Nearby market—Most of Canada's population is concentrated in a narrow strip along the U. S. border. Montreal is located almost in the population center of the most economically important part of this strip—that east of the Great Lakes. Seven of the nation's largest cities, and by far the largest portion of industry, are located in this area.

The local market is a growing, prosperous one, profiting enormously from the current Canadian economic boom. Local industrial growth with its parallel commercial development insures a steady market for refined products. The Montreal center services most of the present market of over 65-million b/yr—Sarnia, Ont., serves most of the rest.

Low-cost transportation—The city of Montreal is built on an island 600 miles from the mouth of the St. Lawrence. Canadian land and air transportation have made it their center, and, after New York, the city is the busiest port in the hemisphere. Ocean-going tankers dock right at the refining area; pipelines carry crude in, products out.

Cheap power—The Laurentian Plain, leading to the famous mountains, starts at Montreal island's north shore. The basin is one of the earth's richest in both available and potential hydroelectric power. More than half of Canada's hydroelectric capacity is installed in the Province of Quebec.

Montreal—refining with a difference

Consider the effects of Montreal's winter. Average low temperature is about 10° F.—equipment is designed to operate down to about —20° F. Winterizing adds about 10% to new construction costs, also boosts operating costs.

Though ocean going tankers can bring crude in, and smaller vessels carry products to markets upstream, these ships operate only seven months of each year. Winter temperatures freeze the river, close the port from December to late Spring.

These same low temperatures cause fuel oil demand to soar in winter, motor gasoline consumption to sag. Refiners have a double problem of adjusting output to meet extremely cyclical demand, and providing enough storage facilities to minimize the effects of their winter-sensitive river. Aggregate storage capacity for the five refineries is almost 22-million bbls.

Power is cheap, as mentioned. Naturally, operations are affected. The ratio of electric to steam power is much higher than the usual average. The new Petrofina plant uses electric power for all outside facilities, can operate up to 70% of its pumps electrically.

Power failures are expected to be a thing of the past. The local utility companies provide direct lines from different networks, with automatic switchover available.

French is the language of over two thirds of Montreal's more than 1.4-million inhabitants. For the refineries, however, language is no problem. Bilingual personnel are plentiful —all foremen, switchboard operators, etc., speak both languages. The oil companies have found the Montrealers to be excellent workers—industrious and inventive. Currently, the labor pool is favorable. Downtown Montreal is less than 10 miles away.

The detail map on page 72 shows one of the most peculiar characteristics of Montreal refining operations. Refinery-size plots of land are normally available only as long strips. This is a legacy from the days when land was apportioned to give the greatest number of owners access to the surrounding rivers. The ruling Seigneurs divided the waterfront into narrow sections and included the long strip behind each one of these in the plot offered to potential landholders.

As a result, most of the plots in the present refining area are long and narrow—not the most efficient shape for refining operations. Lines to tank farms are excessively long, expansion of facilities sometimes poses problems.

To supplement water transportation, a 397-mile product pipeline was built in 1952 from Montreal to Ottawa, Toronto, and Hamilton. It handles 54,000 b/d from four of the area's five plants—Imperial Oil Co., with a refinery at Sarnia, convenient to the Toronto market, does not use the new line.

Most of the incoming crude oil is brought through the 236-mile Portland, Me., to Montreal pipeline, which is fed by tankers from the Caribbean and Arabia.

There are three main crude sources for Montreal:

Venezuela	60-million b/yr
Arabia	7-million b/yr
Kuwait	4-million b/yr

The refineries and petrochemical plants of the Montreal area comprise a tight industrial community. Together with some complementary industry in the same township they add up to possibly Canada's most important industrial area—in terms of contribution to the nation's economy.

(Four of the refineries are in Montreal East, the township that borders on Montreal proper. The new Petrofina plant is across the road from Montreal East, in another township, Point aux Trembles.)

Part of the same industrial complex is a very modern lube oil blending plant, a big copper smelting plant, two copper fabricators, a giant cement plant, a gypsum company, and several oil jobbers.

The companies have formed a mutual fire protection system, and set up an industrial relations-community relations group. The denseness of the community has made for easy relations between firms. In some fields, industrial safety, for instance, there is considerable cooperation.

Montreal as a refining center

	Refineries	Capacity b/d	Product value	Crude value	Wages & salaries	Fuel & elec.	Employes
			—— in millions of dollars ——				
It's big business	5	240,000	345	221	12.25	11	2752
How the rest of Canada compares	39	428,000	633	390	41.2	22	9548
TOTAL—today's Canadian refining picture	44	668,000	978	611	53.45	33.2	12,300

Product consumption in the Montreal market (Quebec and Ontario, 1954)

	Gasoline	Avgas	Light fuel oil	Heavy fuel oil	Diesel	Kerosene and Av lube
bbl/yr	39,793,000	805,000	1,656,000	16,219,000	4,150,000	851,000

The future and the Montreal center

The Canadian economic boom, during which Gross National Product passed the $26-billion mark—an astonishing 10% in 1955—is nowhere more noticeable than in the Montreal area.

A visitor driving in from Dorval airport sees mile after mile of brand-new light industrial installations. Along the highly industrialized south shore, heavy industry is arriving, modernizing, expanding. "Industrial estates" are springing up, adding diversification to an already diversified industrial community. Two steel companies, Krupp and an American

Who's Who in Montreal Refining

British American Oil Co., Ltd.

Fully integrated Canadian company, with five refineries, total capacity over 95,000 b/d, lube oil plant at Clarkson, Alta. Among interests: wholly owned U.S. producing firm—British American Oil Producing Co., 50% interest in B. A. Shawinigan petrochemical plant at Montreal, 18% of crude line from Portland, Me., 33⅓% of line to Toronto.

Ref. address, tel. no.: Sherbrooke St. East, Montreal East, MI 5-5711

City address, tel. No.: Canada Cement Bldg., UN 6-9671

Refinery Mgr., Asst. Mgr.: J. A. McHardy, H. S. Sparrow

Staff: R .C. Beal, Op. Supt.; W. Morrison, Ch. Engr.

J. A. McHardy

Canadian Petrofina Ltd.

Fully integrated, new company, started July 1, 1953, subsidiary of Compagnie Financière Belge des Petroles, of Belgium. Now controls Calvan Consolidated Oil and Gas, and Western Leaseholds, two Canadian Producers. Owns 10% of Portland crude line. Plans marketing operations in U .S.

Ref. address, tel. no.: 11701 Sherbrooke St. East, Point aux Trembles, MI 5-7221

City address, tel. no.: 1015 Beaver Hall Hill, UN 6-8861

Refinery Mgr., Asst. Mgr.: J. A. Alexander, C. Bulatko

Staff: J. Mills, Proc. Supt.; D. R. Ayer, Ch. Engr.

J. A. Alexander

Imperial Oil Limited

Fully integrated, largest Canadian oil company, 60% owned by Standard Oil Co. (N.J.), nine refineries with total capacity of over 270,000 b/d. About 70% of crude used is Canadian. Has 2,000 b/d lube oil plant at Edmonton, Alta., interests in eight pipeline companies, including 40% of crude line from Portland.

Ref. address, tel. no.: 10510 Sherbrooke St. East, Montreal East, MI 5-5881

City address, tel. no.: 1980 Sherbrooke St. West, WE 8671

Refinery Mgr., Asst. Mgr.: D. L. Huggat, J. J. Rowan

Staff: S. J. Voce, Proc. Supt.; L. J. Orr, Ch. Chem.

D. L. Huggat

McColl-Frontenac Oil Co., Ltd.

Fully integrated, about 58% owned by The Texas Co. Manufactures and markets Texaco products in Canada. 11,000 b/d refinery at Edmonton, Alta., wholly owns Trinidad producer, Antilles Petroleum Co. Participates in The Texas Co.'s Canadian production of oil and natural gas. Owns 18% of crude line, 33⅓% of product line.

Ref. address, tel. no.: 10200 Notre Dame St. East, Montreal East, MI 5-5811

City address, tel. no.: 1425 Mountain St., PL 4281

Refinery Mgr., Asst. Mgr.: H. M. Bolitho, E. G. Rosengren

Staff: W. D. Veinot, Ch. Engr.; L. F. Tye, Ch. Chem.

H.M. Bolitho

Shell Oil Co. of Canada, Ltd.

Fully integrated, 50% owned by Shell Oil Co., 10,000 b/d refinery at Vancouver, 70 mmcf/d gas processing, and 80 t/d sulfur extraction plant at Jumping Pond, Alta., petro-chemical plant at Montreal. Produces with Shell Oil in Western Canada. Owns 33⅓% of product line to Toronto, 18% of crude line from Portland, Me.

Refinery address, tel. no.: 10510 Sherbrook St. East, Montreal East, MI 5-5751

City address, tel. no.: 660 St. Catherine St., West, Un 6-7571

Refinery Mgr., Asst. Mgr.: L. T. Wilson, G. A. Lorenz

Staff: T. H. Tedford, Ch. Engr.; E. G. O. Way, Ch. Chem.

L. T. Wilson

major, are planning new mills in the area. The gigantic St. Lawrence Seaway project is making the loudest boom of all. If Imperial Oil's explorations in southern Quebec province bring in oil, the area could pass Ontario and become the nation's industrial center.

Western natural gas seems a certainty for east Canada. Some of the biggest blocks in the path of the long planned $375-million pipeline that will carry the gas east have been removed, and it is most probable that the line will be started shortly, possibly completed next year. The Canadian government seems ready to undertake complete development if all else fails.

If natural gas comes, three foreseeable effects might be: 1—A reduction in the area served by the Montreal refineries; 2—A smaller share of the new customers mushrooming in southern Quebec; 3—A slowdown in rate of fuel oil increase.

The coming of Western crude is not so certain. Although the production is, or will soon be, available, determining economic soundness of the project is proving difficult. The question reduces to whether it is more efficient to bring crude east or to send products west. At least two extensive analyses have been made—Mr. F. G. Cottle, of Imperial Oil concluding that there is little hope for western crude in eastern Canada, and Mr. G. M. Furnival of Standard of California deciding that the eastern market is both competitive and logical for western crude.

If the oil does come east there would be a definite shrinkage of Montreal's refined product market, with a possible smaller than anticipated share for the area in the nation's forecast 6% a year product sales increase for each of the next five years—a demand expected to raise Canadian refining capactiy more than 200,000 b/d by 1960.

Two other effects might be: 1—Decreased importance for the area as a petroleum product distribution center; and, 2—New importance for the products supplied as raw materials to petrochemical manufacturers. The coming of natural gas would no doubt boost petrochemical activity in Montreal.

Net future outlook, however, is still bright. The factors that have aided the area's development should help it hold, for some time, its position as Canada's most important refining area.

Articles on the individual refineries and petrochemical plants in the Montreal area start on p. 76.

FLOW DIAGRAM - BRITISH AMERICAN OIL CO. MONTREAL REFINERY

Montreal refining fact roundup

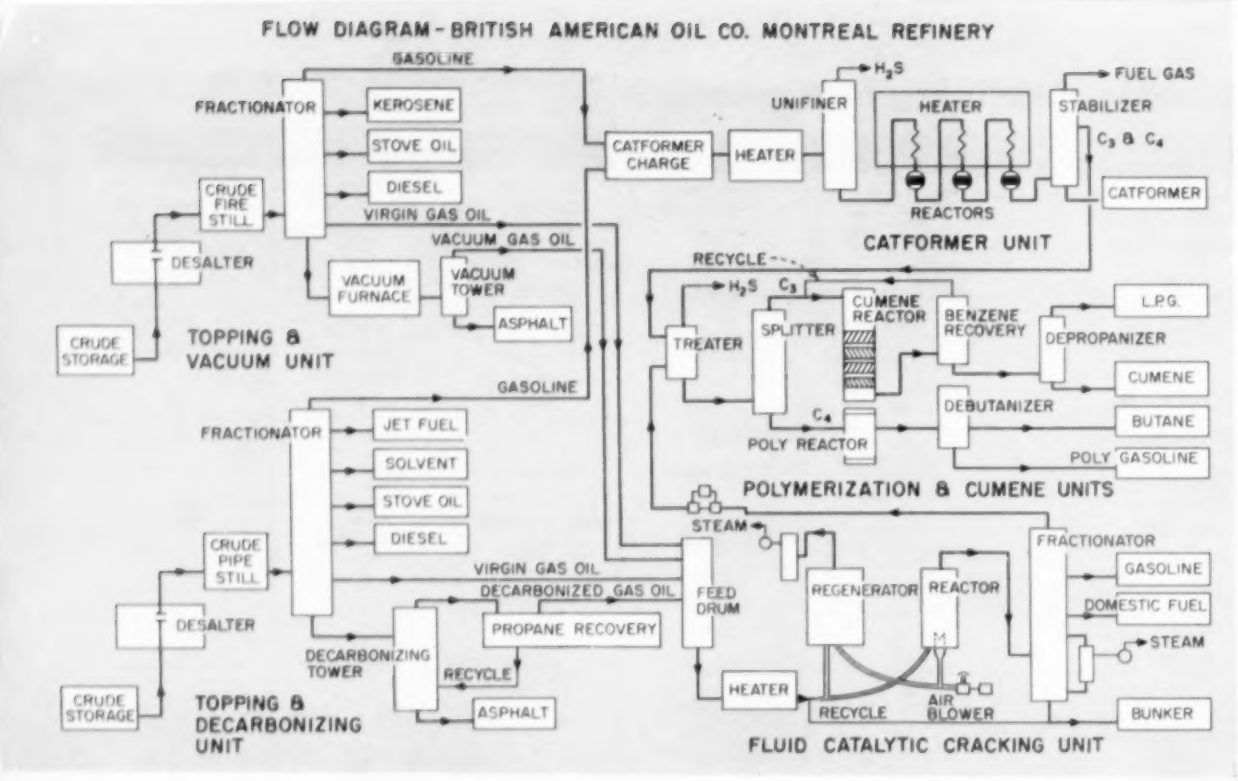
(1956 Capacity—240,000 b/d, Employees—2752, Product Value—$345 Million/Yr.)

GENERAL DATA

Refining companies	British American Oil Co. Ltd.	Canadian Petrofina Ltd.	Imperial Oil Ltd.	McColl-Frontenac Oil Co., Ltd.	Shell Oil Co. of Canada Ltd.
Capacity (b/d.)	45,000	20,000	70,000	50,000	55,000 (Later this year)
Original capacity	8,000	20,000	4,000	500	5,000
Onstream date	1931	1955	1916	1924	1933
Value	$30 Million	$28 Million	$45 Million	$33 Million (Estimated)	$35 Million
Employees	509	150	870	473	750
Acreage	370	350	383	285	320
Crude source	Venezuela Middle East	Middle East	Venezuela	Middle East Venezuela	Venezuela
Crude type	East Venezuela Oficina, Tia Juana Kuwait	Kuwait Iraq	East Venezuela Suanipa Tia Juana	Arabian Light Oficina Mata	Oficina
Approx. yield %					
Gasoline	46	50-63	30	46	45
Middle dist.	30	21.5-30	33	25	35
Bunker	15	6.5-12.5	22	22	15
Other	6 Asphalt 3 Gas Loss	3-3.8 Propane 4.5-5.2 Fuel 600 150 t/d. Coke	6 Asphalt 9 Misc.	9 Gas Loss	5 Gas consumed
How products shipped %					
Pipeline	34	Not yet typical	0	41	28
Tanker	23		36	25	28
Tank truck	30		38	23	26
Tank car	13		26	11	18
Storage capacity, mill. bbls.	4.9	2.0	7.5	3.4	3.75
Product	3.7	1.1	6.35	2.5	2.95
Crude	1.2	0.9	1.15	0.9	0.8

EQUIPMENT DATA (b/d. unless otherwise specified)

Crude topping	45,000	20,000			2 units, 45,000 total + 10,000 under const.
Vacuum distillation	12,000	9,700			2 units 25,000 total
Vis breaking			Jersey 12,000	9,600	
Thermal cracking	3,500 (Discontinued)			4,500	Dubbs 8,000
Catalytic cracking	Kellogg FCCU 18,000	Houdry 16,000	Modified Jersey II 19,000	Kellogg FCCU 23,000	Shell 19,500
Fluid coking		Jersey 150 t/d.			
Thermal reforming			Jersey 4,200	4,500	
Catalytic reforming	Atlantic 13,000	Std. of Ind. Ultraformer 3,600		UOP Platformer 12,000	UOP Platformer 6,600 Under const.
Catalytic polymerization	UOP 630	UOP 290	UOP 5,000 Charge	UOP Kellogg 1,500	UOP 3,500 Charge
Alkylation		Texas 3,000			
Hydrogen desulfurization	Unifiner 16,000 Still in design	Shell 3,000			Shell 7,000 Under const.
Propane decarbonizing	4,000				
Asphalt	5,000 SR 2,000 Oxid		2,000 SR 2,000 Oxid		
Lube oil	330				
Cumene	UOP 365				



BRITISH AMERICAN

Cat Reformer and Cost Control

If any feature of BA's 45,000 b/d refinery can be called a highlight it is the new 13,000 b/d catalytic reformer now about to go into operation. The Atlantic Refining Co. designed unit is the largest of its kind so far built. It will use platinum catalyst and process straight run naphtha for high octane blending purposes.

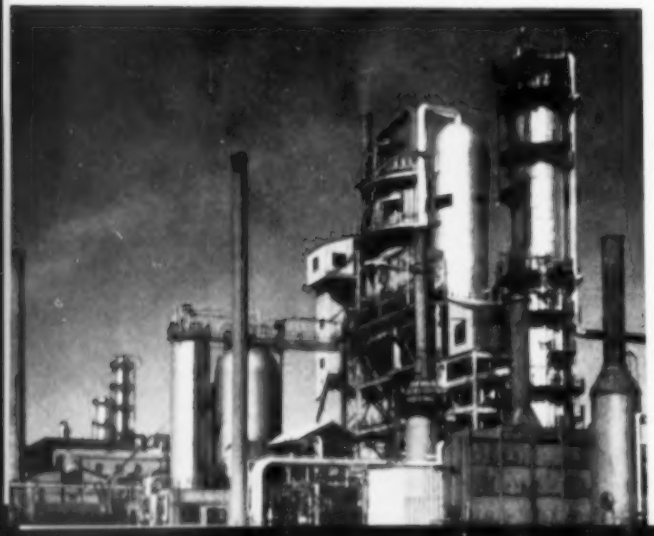
Operating in conjuction with the cat former will be Lummus built hydrogen desufurizer which BA will install to increase flexibility.

Also being installed is a 15,000 lb/hr Babcock & Wilcox CO boiler, which will be the second one in operation anywhere. (A new water softener is going in along with it.)

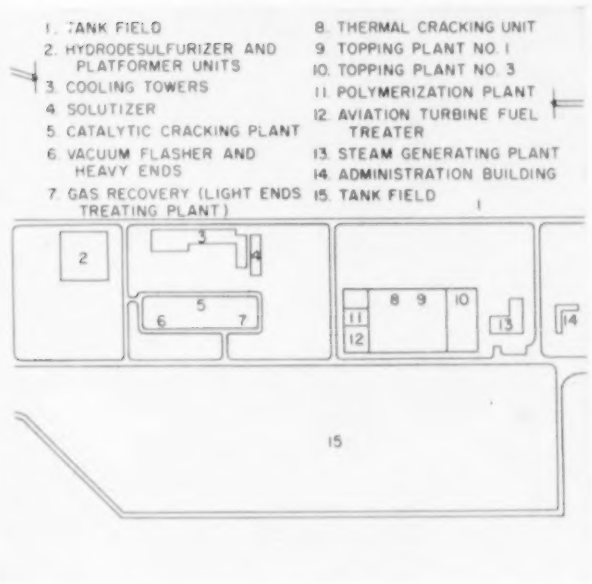
A new, $60,000 mass spectrometer is expected to be doing a large share of BA's analysis work shortly. It is the only unit of its kind in the Montreal refining area. Photo on p. 147.

This Montreal East refinery is the first of British American's to use an elaborate company developed system of operating cost control. Their first-time-in-refining application of graphical statistics is giving department heads and other management men a running check on those costs which deviate from standard, anticipated operating costs.

PROCESS AREA of British American's Montreal East refinery shown in photo and plot plan



FINA'S process area in plot plan and photo



CANADIAN PETROFINA

Ultra-modern, Ultra-efficient

Billed as the world's most modern refinery, and just getting on stream after some start up difficulty, Petrofina's Montreal plant is the latest word in turning crude oil into the most valuable products at lowest cost.

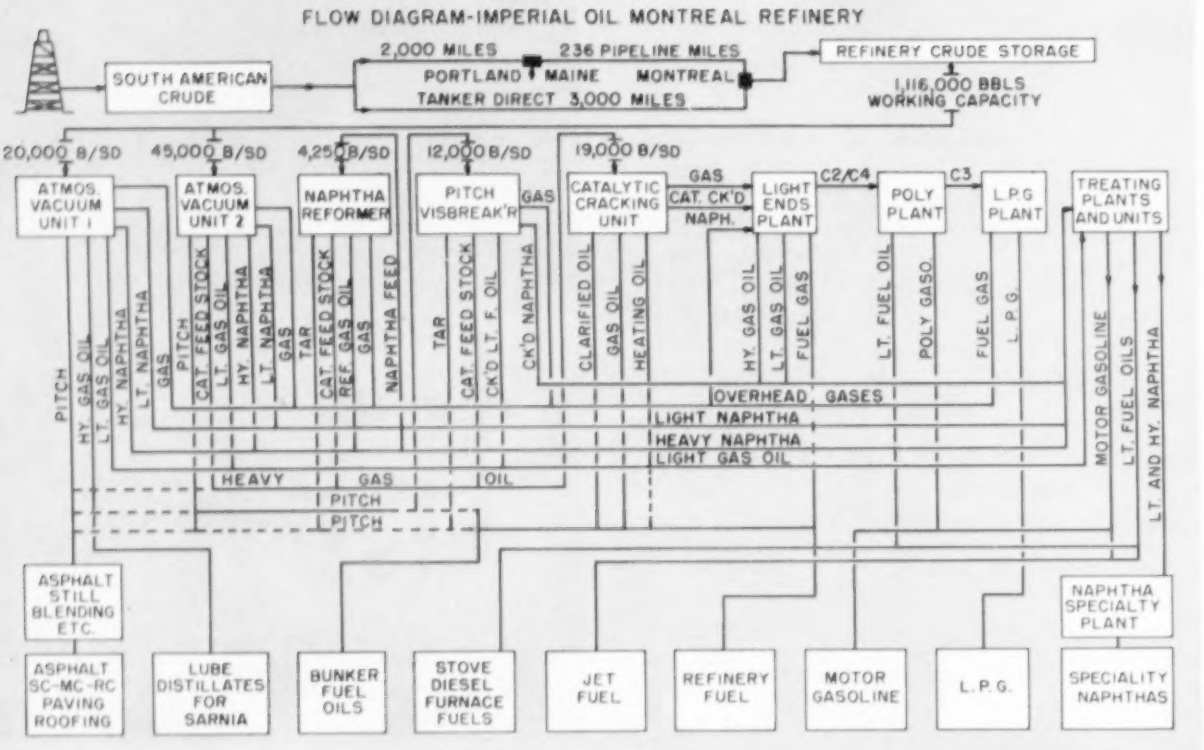
From a ⅛ in. to 1 ft. prominently displayed scale model to the functionally colored process units the refinery gleams with efficiency and functionalism. Completely color-coded the plant shows which units, lines, tanks, and equipment are being used for what purpose. The darkest colors—black, brown, maroon—indicate equipment handling heaviest ends, lightest colors—tan, yellow, white—locate the lightest liquids and gases. Everything is coded including buildings and offsite facilities.

The scheme is repeated on the panel board in the refinery's showplace—the giant, centralized control room. There, miniature Fisher-Porter recorders log 480 points automatically while the comprehensive Panellit-built board shows process conditions with a minimum of cross lines and with main hydrocarbon streams flowing in the same direction. Built into the system are noise alarms and provisions for continuous logging of unusual conditions, as well as means of providing some of the records in forms usable directly for accounting purposes.

At present, charge to the electronically controlled 16,000 b/d Houdriflow catalytic cracking unit is light and heavy gas oil from the refinery's distillation unit. Evenutally, gas oil from the coker will be added. (Although no announcement has been made, near-future expansion, possibly a doubling of capacity, seems certain.) Of the Houdriflow's total charge, 10,000 b/d is fresh feed, the remaining 6,600 b/d, recycle stream heavier than diesel.

Fina has the only Fluid Coker in the area, chosen instead of a delayed coking process because of local winter weather and manpower conditions. Fina is also the only refinery in the area using an outside maintenance service, preferring not to keep its own maintenance crew during this phase of its operation.

FINA'S vapor recovery unit, right



IMPERIAL OIL

70,000 b/d, Largest in the Area

Imperial's Montreal East refinery has the largest capacity of any in the area. With a major construction program recently completed, the plant's capacity is now about 70,000 b/d.

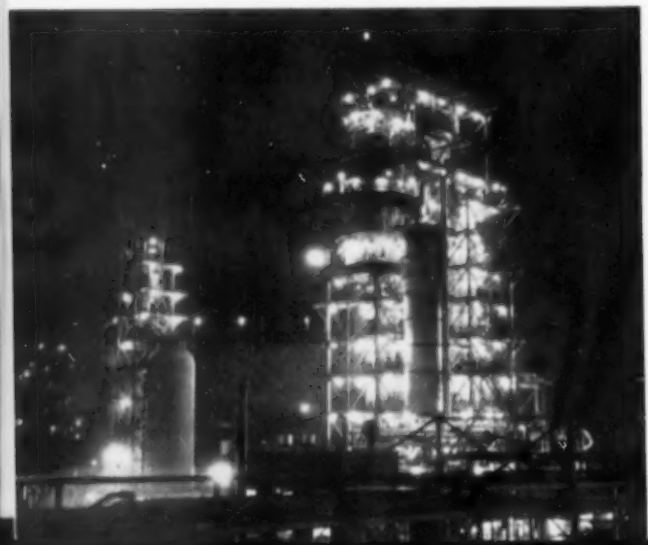
The $15-million modernization program included a new 11,000 b/d vacuum unit to complement an existing pipe still, a 45,000 b/d atmospheric and vacuum unit, and new capacity for the cat cracker. This unit, built in 1943, was the first catalytic cracker in Canada. Its capacity is now 19,000 b/d.

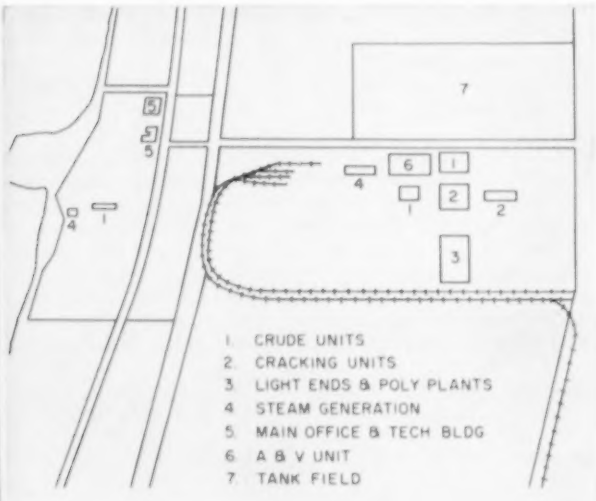
Additional improvements are being made or planned. About $750,000 will be spent to modernize the large asphalt operation, and new tank car loading facilities are being installed. Imperial's current asphalt capacity is 4,000 b/d, half of which is produced as straight run product.

Tank trucks, which transport the largest volume of products from the refinery, are now loaded from a modern, centrally controlled station. Drivers order through pneumatic tubes, are instructed over loudspeakers.

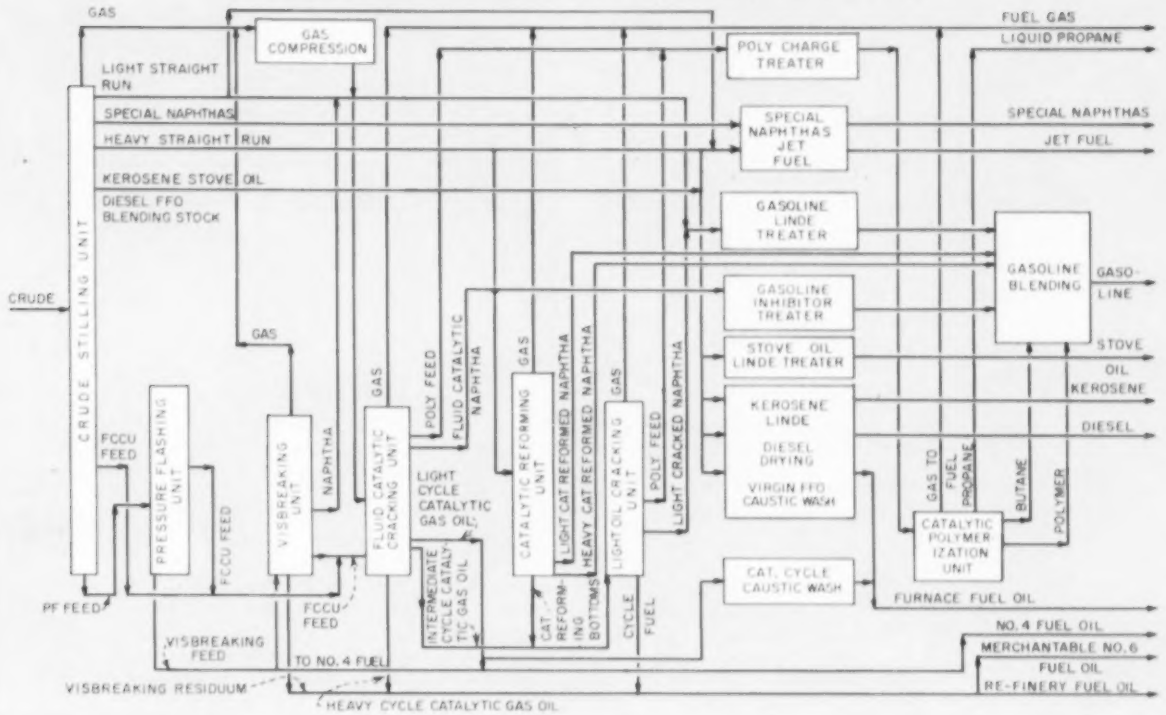
Shop facilities are centralized and newly modernized. Both crude units, the larger of which was built by Imperial's engineering division, are controlled from a common control room.

PROCESS AREA of Imperial's Montreal refinery in photo and plot plan





FLOW DIAGRAM - M. COLL - FRONTENAC MONTREAL REFINERY



McCOLL-FRONTENAC

Canada's only Unifiner-Platformer

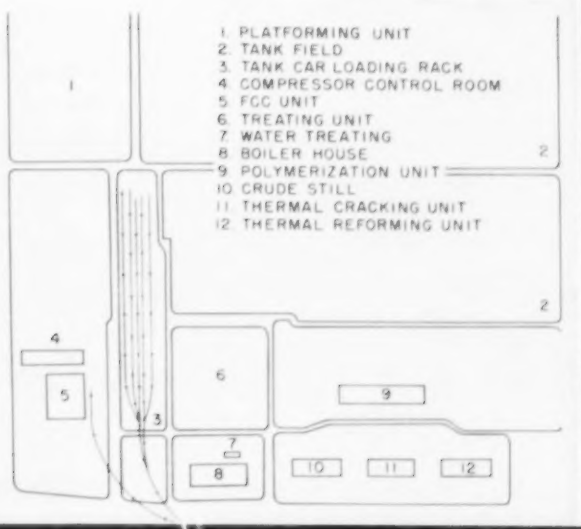
Capacity at McColl-Frontenac's Montreal refinery, which was about 43,000 b/d two years ago, is 50,000 now, will be 58,000 b/d shortly. And, as are the other refining companies in the area, McColl-Frontenac is installing equipment to boost product quality in anticipation of future requirements.

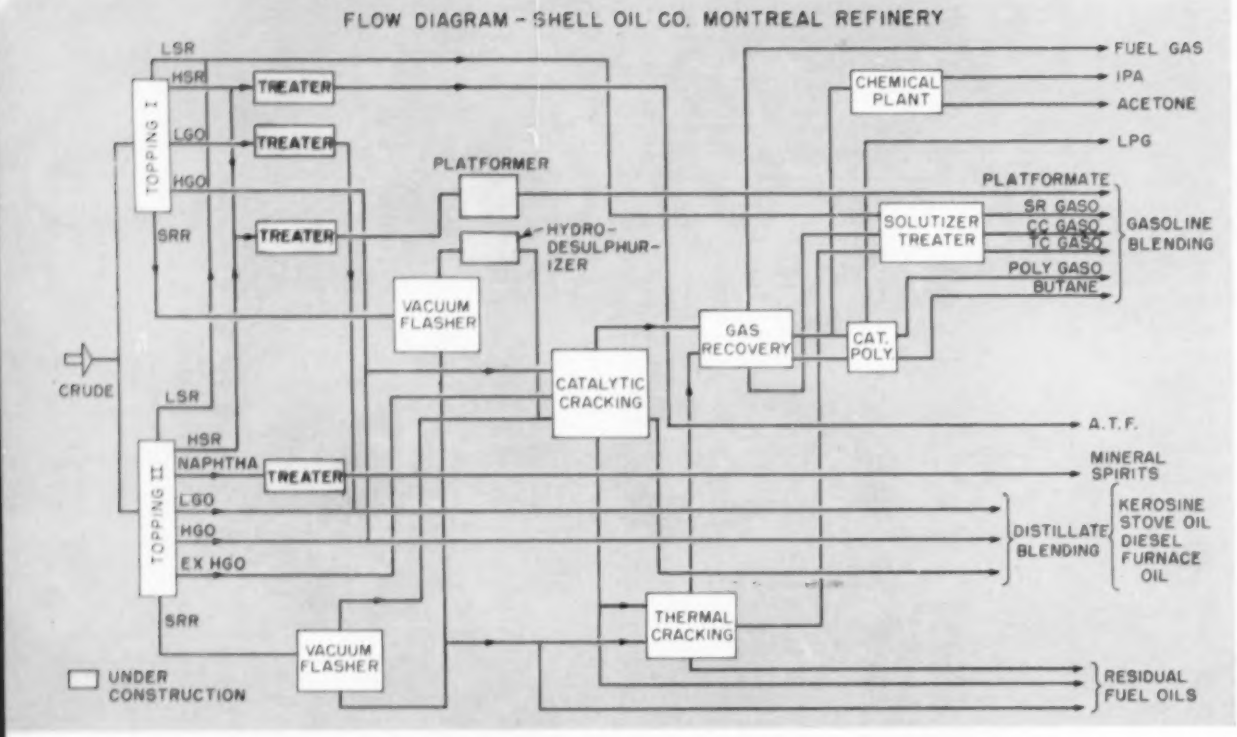
A 12,000 b/d combination UOP Platforming-Unifining unit designed to produce leaded octane Platformate of 95 was put on stream in mid-1955. This unit was the first of its type on stream outside the U. S. and is probably the only one in Canada. The combination unit, which is replacing a 4,500 b/d thermal reformer, is now charging heavy straight run from the crude stills.

Two additional coolers were recently installed for the 23,000 b/d Fluid cat cracker. Later this year, a distillate desulfurizer will be built.

One of the features of the refinery is Canada's largest inert gas filled synchronous motor, a Westinghouse 4,000-hp model which drives the platformer's centrifugal hydrogen compressor. Another giant, a GE 2,000-hp, slow speed, synchronous motor drives the Fluid cat cracker's reciprocating compressor.

PROCESS AREA of McColl-Frontenac's Montreal refinery in plot plan and photo





SHELL OIL OF CANADA

Ever Changing, Ever Growing

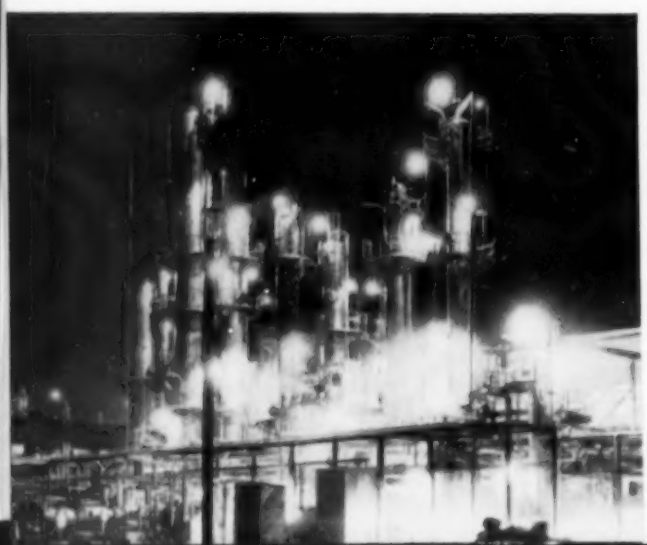
When Shell completes the third phase of its current $14-million expansion program this summer it will be the world's first refinery to apply hydro-desulfurization to heavy cat cracker feedstock.

The program's $4-million first phase, now completed, brought in a A. G. McKee Co. built vacuum flashing unit, and expanded cat cracking capacity by 3,000 b/d—to 19,500. In the second phase, crude oil distillation facilities are being expanded. In this operation some parts of the original Dubbs unit will be retained.

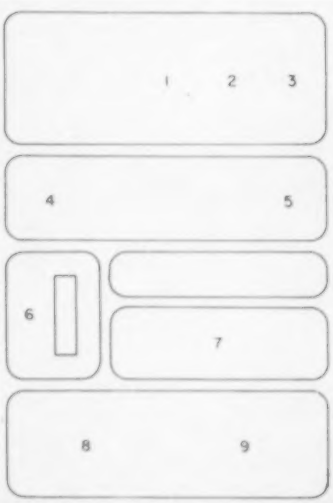
A Platformer for reforming heavy straight-run naphthas, and the 7,000 b/d hydro-desulfurizer for treating flashed distillate feed to the catalytic cracking unit are third phase improvements.

At the same time, utility and other facilities supporting the major process additions will be expanded. Over $4-million is being spent on a new cooling water tower of 18,000 gpm capacity, two 60,000 lb/hr steam boilers, additional gas recovery and treating facilities, more storage capacity—for both crude and product, a new electrical power distribution system, and other improvements designed to boost capacity to 55,000 b/d.

PROCESS AREA of Shell's Montreal refinery in photo and plot plan



1. FLUID COKER
2. VACUUM UNIT
3. CRUDE TOPPING UNIT
4. CAT REFORMER
5. TREATER
6. CONTROL HOUSE
7. CAT POLYMERIZATION & ALKYLATION
8. VAPOR RECOVERY
9. HOUDRIFLOW* CAT CRACKING
10. OPEN AREA



Petrochemicals— slow start but bright future

Montreal's petrochemical industry is sizeable. It's logical. The five refineries plus the advantages described earlier have made the area Canada's second most important in petrochemical manufacture. Sarnia, with its easy access to the Canadian rubber producers and some nearby refineries, is the nation's petrochemical leader. Plant alone at Sarnia is valued at well over $100-million.

Why isn't Montreal's petrochemical operation larger? Big reason, of course, is size of the market. Until recently Montreal was not able to support substantial petrochemical operations. Though this situation has changed with the extraordinary postwar growth of Southern Quebec, local petrochemical industry got off to a late start.

Two other factors hampering growth are:

1—Winter costs which boost both operating and first construction costs, and

2—Competition with U. S. petrochemical manufacturers whose larger markets often permit them to produce for less.

At this point, the tariff snake raises its head. There is certainly fierce pressure on Ottawa to strengthen a relatively flimsy tariff wall against chemical imports. But the combination of: 1—Canadian government determination to remain, for a while at least, a free trade leader, both in advocacy and practice; and, 2—An administration desire in Washington to avoid unfavorable comment on tariff increases, makes it likely that before Canadian producers force tariffs up, Washington might find a way to ease entry of their products here.

It wasn't until 1953 that the first of the Montreal area's plants went up. That year, despite the prospect of marginal operation, four plants were completed and producing within a few months of each other.

The products were:

- Acetone and isopropyl alcohol at Shell Chemical.
- Phenol and acetone at B.A.-Shawinigan.
- Glycols at Canadian Carbide (new owner—the plant was originally built by Dominion Tar and Chemical).
- Formaldehyde and pentaerythritol at St. Maurice.

B.A.-SHAWINIGAN LTD.

When this plant, half owned by BA Oil, half by Shawinigan Chemical, was completed in April, 1953, it was the world's first using the new Hercules Powder-Distillers Corp. process for manufacturing phenol and acetone from cumene.

It now produces more than 13-million lb/yr of phenol, 8-million lb/yr of acetone—well over its design capacity—as well as alphamethylstyrene and acetophenone as byproducts, all at yields comparable to those of the usual chlorination and sulfonation processes for phenol, requiring neither chlorine or sulfur. Flexible design permits using some of the phenol and acetone output for isopropyl alcohol production. When the new catalytic reformer goes on stream at BA's Montreal refinery, hydrogen will be available for alcohol production by hydrogenation.

The $4-million, Kellogg-designed-and-built plant employs about 75 and is built on 5 acres of a 21 acre site—indicating considerable future expansion potential. It is not enclosed, as is Shell's plant described below, therefore it shows many signs of winterized construction. Though the average winter low in the area is about 10° F. designs usually provide for protection down to —20° F. These low temperatures make continuous operation quite difficult. Steam tracing, particularly, being critical, over 15 miles of copper tubing is used for this purpose alone.

MONSANTO CANADA LTD.

In a plant at Ville LaSalle, on Montreal island's Southwestern shore, Monsanto produces polystyrene, other petrochemicals, and two petroleum additives and some pharmaceuticals in a plant originally built by Mallinkrodt Chemical Works in 1932.

ST. MAURICE CHEMICALS

A joint venture of Shawinigan Chemicals Co. and Heyden Chemical Corp., St. Maurice's plant was brought on stream in September, 1953, within a few months of the Shell and B.A.-Shawinigan installations. The plant is located at Varennes, on the south shore of the St. Lawrence, close to the city.

Planned total production of formaldehyde and pentaerythritol at the $3-million plant is 30-million lb/yr. Synthetic methanol is the basic raw material. From it, formaldehyde is produced by oxidation and dehydrogenation.

Pentaerythritol is made by reacting the formaldehyde with acetaldehyde in a controlled temperature alkaline medium. Some tripentaerythritol is also produced.

SHELL OIL CO. OF CANADA, CHEMICAL DIVISION

Shell's isopropyl alcohol and acetone plant was the first strictly petrochemical plant in Canada. In fact, when the $4.8-million, C. F. Braun designed plant was opened in April, 1953, acetone was not then being made from petroleum derivatives anywhere.

The plant is totally enclosed and probably the only unitized installation of its kind in Canada. A giant reversible fan at one end of the building provides sufficient air changes and helps maintain proper temperatures. The trend today in Canada is away from enclosed structures.

Though design capacity is about 12-million lb/yr of IPA, and 8-million lb/yr of acetone, current market demand keeps the plant operating well above those figures. Output has probably reached 300% of design capacity. As in the BA-Shawinigan plant described above, great flexibility is available for adjusting output of the main products to meet current conditions.

IPA is produced by reacting propane-propylene from the adjoining Shell refinery with sulfuric acid, and then hydrolizing the resulting esters.

Acetone is made by catalytic dehydrogenation of the isopropyl alcohol.

UNION CARBIDE OF CANADA, LTD.

This $12.4-million plant went on stream in May, 1953. It uses local refinery gases to make ethylene which is then processed by the dichlorohydrin method into ethylene glycol, ethylene oxide, proylene glycol, propylene oxide, and other chlorinated products. (Chlorine comes from a Dominion Tar and Chemical plant nearby at Beauharnois, on the south side of the St. Lawrence). The refinery gases are made to yield the ethylene by an unusual low temperature fractionation process. Total output is well over 30-million lb/yr.

New Process Design Methods for

Optimum Bubble-Cap Tray Design

PART II–DESIGN STANDARDS

By WILLIAM L. BOLLES, Manager of Process Design

Monsanto Chemical Co., Texas City, Texas

THE previous discussion has been concerned entirely with methods for making tray dynamic calculations. This provides the foundation for tray design. However, it is also necessary to establish *standards* for tray design in order to provide the basis for selecting tray design components which will assure that the required performance will be attained.

These standards will begin with a discussion of materials of construction. General tray types will be recommended, followed by downcomers and weirs. Every factor in the design of bubble-caps will be treated, concluded by presentation of a proposed set of standard bubble-caps for general use.

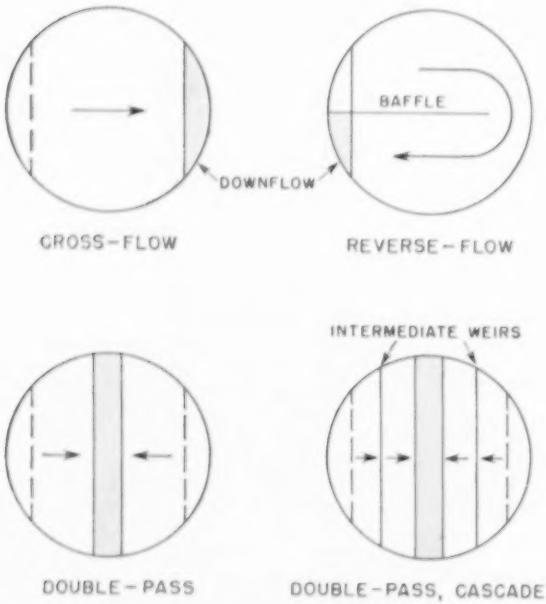


Fig. 21—**RECOMMENDED GENERAL TRAY TYPES,** including cross-flow, reverse-flow, double-pass, and double-pass cascade

This will be followed by recommendations on cap pitch, spacing, skirt height, and means of cap fastening. Then standards will be developed for every element of tray dynamics. Finally, standards will also be proposed on tray spacing, inlet and intermediate weirs, reverse-flow baffles, bubble-cap clearances, redistribution baffles, seals, deflections, drainholes, packing, and construction tolerances.

Materials of Construction

Bubble-cap trays have been constructed of cast iron, sheet carbon steel, and sheet metal of various alloys. Cast iron caps and trays used to be common. However, they are very heavy and require heavy foundations and tower structures. Furthermore, cast iron caps are thick and are consequently wasteful of column cross-sectional area.

Sheet metal trays and caps overcome these disadvantages, as well as being cheaper. Carbon steel trays are considerably cheaper than cast iron. Furthermore, pressed caps and trays of 11-13% chrome in the gage metal thicknesses are competitive with cast iron trays. As a result, cast iron trays are seldom specified anymore.

Nearly all of the common metals and alloys have been used in the construction of sheet metal trays and caps. Low carbon steel is the usual standard for non-corrosive service. The use of other metals and alloys are dictated by the conditions of corrosion expected. In order to indicate the effect of materials of construction on cost, the following relative tray costs are illustrative of some of the common metals and alloys:

Material	Relative Tray Cost
Carbon Steel	1
11-13% Chrome Type 410	2
18-8 Type 304	2½
18-8 Moly Type 316	3½
Monel	4

General Tray Types

General tray types are classified by the mode of liquid flow on the tray. The more common and recommended tray types are illustrated in Fig. 21.

The cross-flow tray, wherein the liquid flows directly across the tray, is the most common tray type. This represents the simplest tray construction, and is consequently the most economical to fabricate. In addition, the long liquid path across the tray contributes to high plate efficiency.

In the reverse-flow tray, the downcomers are all located on one side of the column, and the liquid is forced to flow around a center baffle, reversing its direction at the far side of the tray.

The reverse-flow tray provides more cap area at the expense of downcomer area. It should be evident that the liquid path is quite long, and hence this tray tends toward high liquid gradients. The reverse flow tray is advantageous only for very low liquid/vapor ratios.

In the double-pass tray, the liquid flow is split into two portions, each flowing across half the tray. Not only is the liquid load per unit tray width cut in half, but it should be apparent that the length of each liquid path is also cut in half. As a result of these two factors, it should be evident that the double-pass tray provides considerably more liquid capacity and less liquid gradient than the simple cross-flow tray.

Consequently, the double-pass tray is particularly advantageous for high liquid/vapor ratios, or large tower diameters. However, it should be realized that the double-pass design costs from 10 to 15% more than a cross-flow tray of the same size.

If even more liquid capacity is required, intermediate weirs may be provided to give the double-pass, cascade tray. This cuts the liquid path for each bubble-cap section in half again, as compared to the basic double-pass tray. This tray is recommended only for very high liquid/vapor ratios, or very large tower diameters.

In addition to the tray types shown in Fig. 21, numerous other types have been employed.[10,19,25]* However, they are recommended only in special cases.

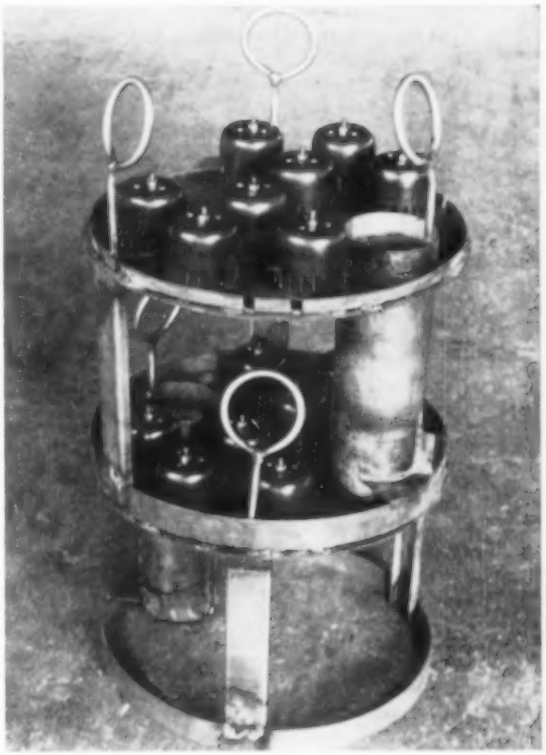
Tray Construction

Bubble-cap trays are either of removable or non-removable construction. The most common type of removable tray is designed to be passed in sections through manholes. The bubble-caps are removable, and are bolted in place. The tray parts are also bolted together and designed to be removable through manholes which are located in the column shell.

This type of tray is easily installed, maintained and repaired, and is recommended for most applications. However, it is limited to columns 2½ ft. in diameter and larger, as this is about the minimum space in which a man can work inside a column.

The so-called cartridge tray was designed to fill the need of removable bubble-cap trays for smaller column diameters. These trays are installed in columns which are flanged at the top. The trays are built in cartridges which are designed to be slipped in and stacked on one another in the column. The construction of this type of tray is illustrated in one of the accompanying photographs. The cartridge tray is recommended for tower diameters less than 2½ ft.

Trays may also be designed to be removed by dismantling shell flanges. These trays are usually built in one piece, and the column flanged every tray or in sections containing several trays. This type of construction is expensive both in original and maintenance cost, and is not recommended except in special applications.



Courtesy of Fritz W. Glitsch & Sons

CARTRIDGE TRAY FOR 17-INCH ID COLUMN. This design permits installation of bubble-cap trays in the smallest of columns

In the case of non-removable construction, the trays are welded into the column. In the larger installations, a manway can be provided in the column, and passage ways built into the trays so a man can work his way down through the column for inspection and minor repairs. This represents the cheapest construction but tray inspection, cleaning, or repair is difficult and costly. Consequently, this type of construction is not recommended except in case of exceptionally clean, non-corrosive service.

For more details on tray construction, the reader is referred to Davies.[10]

Downcomers

Circular downflow pipes used to be a common form of downcomer. This type of downcomer provides very low downflow area, and poor vapor disengaging space. Circular pipe downcomers usually constitute the first bottleneck to column capacity, and are now considered obsolete.

The segmental downcomer is the recommended type. This type provides maximum utilization of column area for downflow, and results in greatest downflow capacity. In order to further insure maximum downflow capacity it is recommended that the specifications stipulate that the tray support rings not extend through the downcomers.

The downflow baffle constitutes the internal wall of the segmental downcomer. Sometimes this baffle is inclined so that the bottom is closer to the tower wall than

*All references are listed in Part I, PETROLEUM PROCESSING, Feb. 1956, pg. 80.

the top in order to increase the area available for bubble-caps. However, the additional cap area thereby provided is very small. Also, the inclined baffle tends to restrict vapor disengaging capacity at the bottom of the downcomer. Furthermore, the inclined baffle adds to tray fabrication costs. Therefore, vertical downflow baffles are recommended as the standard for tray design.

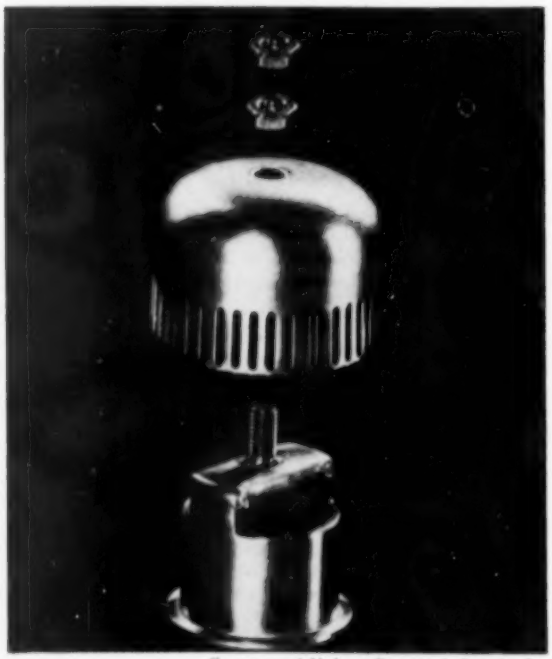
Overflow Weirs

The straight overflow weir is normally recommended. The height of liquid over the weir should be at least one-quarter inch in order to provide adequate liquid distribution.

In the case of lower liquid loads, notched weirs are recommended in order to improve distribution. However, it is recommended that the depth of the notches not exceed ½ inch. This provides greater capacity in case high liquid loads are encountered.

It is recommended that overflow weirs be specified with a vertical adjustment of one to two inches. This provides for adjustment of slot seal (1) to permit extended operation at high plate efficiency with low loads, (2) to provide greater flexibility for new services, (3) to provide insurance against errors in judgment in the original weir setting, (4) to facilitate initial leveling of the weir.

Some designers set limits for the length for the overflow weirs, as 60-80% of column diameter. It is felt, however, that the length of the weir, and consequently the size of the downcomer, should not be restricted by any arbitrary limit. Rather, the most economical tray design should be developed by determining the optimum balance between downflow and tray areas in consideration of the liquid/vapor ratio and the type of tray. A future installment will demonstrate how this is accomplished.



Courtesy of Vulcan Copper & Supply Co.

RECOMMENDED TYPE OF BUBBLE-CAP, round, bell-shaped, pressed-steel, removable design with rectangular or trapezoidal slots and shroud ring

Bubble-Cap Design

Type: Many types of bubble-caps have been employed. However, the round, bell-shaped cap is most widely used. This type of cap, which is illustrated in the accompanying photograph, is believed to be the most efficient and versatile. Hence it is recommended for all trays.

Size: The most common range of bubble-cap sizes is from 3 to 6 in. in diameter. Some designers feel that the smaller bubble-caps result in higher plate efficiencies. Data to prove this are not presently available. However, it is a fact that trays employing the smaller caps cost more for the same tray area and proportionate cap spacing. For example, the following comparative costs are typical of the effect of cap size on overall tray cost:

Cap Diameter, in.	Relative Tray Cost
6	1.0
4	1.2
3	1.35

The additional cost of smaller caps is compensated somewhat by the more efficient arrangement possible in small towers.

As a rough guide for the selection of cap diameter, it is recommended that the cap size be chosen on the basis of column size as follows:

Tower Diameter, ft.	Cap Diameter, in.
2.5-4	3
4-10	4
10-20	6

However, it should be realized that experimentation with tray layouts may indicate the advisability of deviating from the above recommendations.

Wall Thickness: U.S. Standard gage is the standard for the specification of carbon steel and alloy sheet metal thicknesses. The gage numbers and corresponding thicknesses commonly used for bubble-caps are as follows:

12-gage	0.109 in.
14-gage	0.078 in.
16-gage	0.062 in.

For alloy construction, 16-gage metal is recommended for both caps and risers. This thickness provides sufficient structural strength and rigidity while at the same time keeping the cost to a minimum.

In the case of carbon steel caps, heavier construction is recommended because of the relatively cheap material of construction. Also, some corrosion may be encountered, even where not originally expected.

Trays fitted with 12-gage carbon steel caps cost only about 7-9% more than those with 16-gage caps, and will provide an additional corrosion allowance of about 0.05 inches. Therefore, 12-gage thickness is recommended as the standard for carbon steel caps and risers.

Slot Design: The most commonly used *slot shapes* are triangular, rectangular, trapezoidal, or minor variations thereof.

In order to provide a basis for the selection of slot shape, the performance of bubble-caps employing these three shapes was compared. This comparison was based on a 4-in. cap with a slot height of 1.25 in. The mean slot width was held constant at 0.25 in. in order to maintain constant area per slot.

In the case of the cap with triangular slots, the slot width was 0.50 in. at the bottom. The slots were spaced

as close together as practical from a fabrication standpoint, which is about 1.5 times the metal thickness. For caps constructed of 12-gage metal, this resultted in a maximum of 19 slots, giving a slot area of 5.9 sq. in. per cap.

In the case of the cap with rectangular slots, the slot width was 0.25 in. A minimum recommended tooth width of 0.25 in. was employed, which resulted in a maximum of 25 slots or 7.8 sq.in. slot area per cap.

For the cap with trapezoidal slots, the slot width at the top was taken at 0.5 times the width at the bottom, or 0.167 in. at the top, and 0.333 in. at the bottom. With a minimum slot spacing 1.5 times the thickness of 12-gage metal, this resulted in a maximum of 26 slots or 8.1 sq.in. slot area per cap.

In order to compare the slot performance of these three bubble-caps, a system was chosen consisting of the distillation of benzene at atmospheric pressure. The slot performance was then calculated based on the slot opening and slot capacity equations previously given.

The calculated results are presented in Fig. 22. This diagram shows that for any given load the triangular slots give the largest slot opening, and consequently the greatest slot stability at low loads. The rectangular slots, on the other hand, provide the greatest capacity at maximum slot opening.

A quantitative comparison of the calculated maximum and minimum capacity (assuming a minimum stable slot opening of 0.5 in.) is as follows:

Slot Shape	Max. Cap., cfs	Min. Cap., % Max.
Triangular	0.47	10
Trapezoidal(R_s=0.5)	0.74	20
Rectangular	0.77	25

Because of the limited capacity of triangular slots, this shape is not recommended. The performance of the trapezoidal and the rectangular slots is very similar. The rectangular slots indicate slightly higher ultimate capacity, whereas the trapezoidal slots indicate slightly greater flexibility.

Actually, these two slot shapes are considered a standoff in view of the approximate nature of the equations used in the calculations. Therefore, an arbitrary decision is made in favor of trapezoidal slots with a shape factor of 0.5.

Slot widths ranging from ⅛ to ½ in. or more have been employed. Narrow slots theoretically favor plate efficiency because the vapor is broken up into smaller bubbles thereby providing greater interfacial contact area. Wide slots, on the other hand, are somewhat cheaper to fabricate. A reasonable compromise in mean slot width is believed to be about ¼ in.

Slot heights commonly used include the range from ½ to 2 in. Low slot heights limit slot capacity. On the other hand, there is a limit to maximum useful slot height because at the greater height other tray dynamic factors become controlling. The recommended slot height is in the range of 1 to 1½ in., depending on the cap size, as follows:

Cap Size, in.	Slot Height, in.
3	1.00
4	1.25
6	1.50

Slots punched in caps so as to leave the bottom of the slots open, that is, with no *shroud ring*, are used by some designers in the belief that cap pressure drop will be lower when the slot capacity is exceeded.

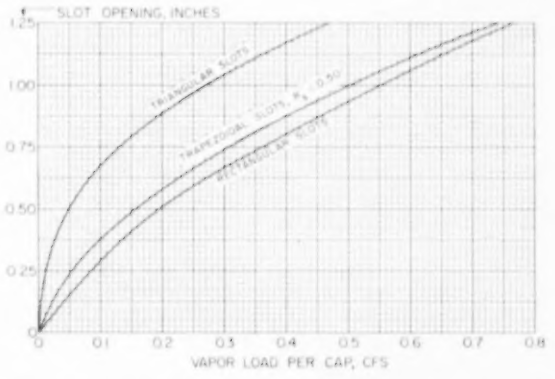


Fig. 22—**PERFORMANCE COMPARISON FOR COMMON SLOT SHAPES**, using 4-in. bubble-caps with 1.25-in. slot height. System is benzene at atmospheric pressure

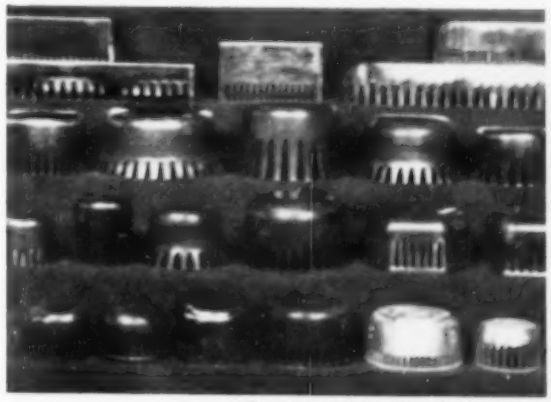
However, the incremental pressure drop per tray resulting from a shroud ring amounts in liquid head to only the height of the shroud ring itself, which is negligible. Caps with open bottom slots, on the other hand, have weak teeth and are subject to deformation in normal handling. Therefore a shroud ring is recommended on all caps, the height of the ring being about ¼ in.

Riser Diameter: After selection of the cap diameter, the riser diameter can be fixed. Small risers minimize annular pressure drop, but contribute to high riser drop. Large risers, on the other hand, give just the opposite effects.

It has been previously shown (Fig. 14) that for optimum cap design with minimum pressure drop, the annular/riser area ratio should be in the range 1.1-1.4. This, then, fixes the riser diameter.

Reversal Area: The reversal area is that area between the top of the riser and the under surface of the roof of the cap. It is recommended that this area be greater than either the riser or the annular area in order to avoid a flow restriction. This can be proved by analysis of the Dauphine equations.

Riser-Slot Seal: The riser-slot seal is the vertical distance between the top of the riser and the top of the slots. Some seal is necessary in order that the liquid will



Courtesy of Fritz W. Glitsch & Sons

A FEW OF THE MANY VARIETIES OF BUBBLE-CAPS available today

not splash down the risers during normal operation. One-half inch is regarded as a reasonable seal for caps in the 3-6 in. range.

Standard Bubble-Caps

Literally hundreds of different bubble-cap designs have been employed. Actually, experimental data to demonstrate the effect of cap design on performance are almost totally lacking. The many and varied designs used have resulted mainly from the whims of individual tray designers.

In an attempt to simplify the process of tray design, a set of proposed "standard bubble-caps" has been developed. The use of standard caps should result in (1) less time spent in design, (2) less inventory of replacement parts, (3) easier cap re-purchasing and (4) more readily reusable surplus caps. Furthermore, if a large number of designers used the same cap designs, the cost of the bubble-caps could probably be reduced.

In developing the standard cap designs, provision was made for a range of cap sizes in order to fit a wide range of column diameters. The cap thicknesses include both 12 gage for carbon steel and 16 gage for alloy construction. Variable riser heights are provided in order to permit variation in skirt height for optimum tray dynamics. The other variables in cap design were chosen in accordance with the preceding discussion.

The resulting proposed standard bubble-caps are presented in Table 4. There are basically six different bubble-caps consisting of three sizes for carbon steel, and three sizes for alloy construction. In addition, there are three riser heights for each cap, as shown.

It is readily admitted that many of the dimensions for the standard bubble-caps are arbitrary. However, it is believed that these caps are simple, sturdy, efficient and economical. At least, there are at the present time no published data available to prove otherwise.

Table 4—Proposed Standard bubble-cap designs

Material	Carbon Steel			Alloy Steel		
Nominal size, in.	3	4	6	3	4	6
Cap						
U.S. Standard gauge	12	12	12	16	16	16
OD, in.	3.093	4.093	6.093	2.999	3.999	5.999
ID, in.	2.875	3.875	5.875	2.875	3.875	5.875
Height overall, in.	2.500	3.000	3.750	2.500	3.000	3.750
Number of slots	20	26	39	20	26	39
Type of slots	Trpzl.	Trpzl.	Trpzl.	Trpzl.	Trpzl.	Trpzl.
Slot width, in.						
Bottom	0.333	0.333	0.333	0.333	0.333	0.333
Top	0.167	0.167	0.167	0.167	0.167	0.167
Slot height, in.	1.000	1.250	1.500	1.000	1.250	1.500
Height shroud ring, in.	0.250	0.250	0.250	0.250	0.250	0.250
Riser						
U.S. Standard gauge	12	12	12	16	16	16
OD, in.	2.093	2.718	4.093	1.999	2.624	3.999
ID, in.	1.875	2.500	3.875	1.875	2.500	3.875
Standard heights, in.						
0.5-in. skirt height	2.250	2.500	2.750	2.250	2.500	2.750
1.0-in. skirt height	2.750	3.000	3.250	2.750	3.000	3.250
1.5-in. skirt height	3.250	3.500	3.750	3.250	3.500	3.750
Riser-slot seal, in.	0.500	0.500	0.500	0.500	0.500	0.500
Cap areas, sq. in.						
Riser*	2.65	4.80	11.68	2.65	4.80	11.68
Reversal	3.99	7.30	17.40	4.18	7.55	17.80
Annular	3.05	5.99	13.95	3.35	6.38	14.55
Slot	5.00	8.12	14.64	5.00	8.12	14.64
Cap	7.50	13.15	29.0	7.07	12.60	28.3
Area ratios						
Reversal/riser	1.50	1.52	1.49	1.58	1.57	1.52
Annular/riser	1.15	1.25	1.20	1.26	1.33	1.25
Slot/riser	1.89	1.69	1.25	1.89	1.69	1.25
Slot/cap	0.67	0.62	0.50	0.71	0.65	0.52

*Allowing for ⅜-in. hold-down bolt

Bubble-Cap Pitch

Triangular cap pitch is recommended because this gives the maximum number of bubble-caps per unit per tray area for any given cap spacing.

The orientation should be so that the rows are normal to liquid flow. With the rows parallel to the liquid flow the liquid gradient will be less, but there is too great a possibility that the liquid near the tray floor can flow across the tray without contacting vapor.

The spacing of the bubble-caps has a pronounced effect on the required column size. The minimum allowable cap spacing is not known but it is known that if the spacing is too close, the bubbles from adjacent cap slots will coalesce thereby decreasing tray efficiency. It is also known that good tray efficiencies have been obtained with cap spacings down to 1 in.

There is also an upper limit to cap spacing, at which point it is possible for the liquid to flow between the caps without satisfactory contact with vapor. Good efficiencies have been obtained with cap spacings up to 3 in.

Hence it is concluded that the practical range of cap spacing lies between 1 and 3 in. The selection of cap spacing within this range involves a determination of the optimum balance of tray dynamic factors, which will be covered in a later installment.

Cap Skirt Height

The lower limit of cap skirt height is obtained when the shroud ring fits flush with the tray floor. However, it has been found advisable to employ a skirt height of at least ½ in. in order to avoid excessive liquid gradient and to provide a space for the settling of sediments.

There is also an upper practical limit to skirt height when the liquid can pass under the caps without adequate contact with the vapor. Good performance has been obtained with skirt heights up to 1½ in.

Therefore, the recommended range of skirt height is from ½ to 1½ in. The selection of skirt height within this range involves determining the optimum balance of tray dynamic factors, which will also be covered in a later installment.

Fastening of Caps

The use of hold-down bars to fasten caps used to be common. Davies,[10] however, has clearly shown that hold-down bars are very undesirable because of their contribution to high liquid gradients.

It is recommended that the caps be fastened by means of bolts. It is also recommended that the fastening be designed so as to permit removal of both caps and risers for maintenance. Cap designs are available so that the installation or removal of caps may be carried out entirely from above the tray, which is a great convenience.

Tray Dynamics

Slot Opening: When the slots are overloaded, the surplus vapor will blow under the shroud ring. This portion of the vapor will not form as fine bubbles as that passing through the slots. Study of commercial fractionator performance has shown that some overload of slots is possible without appreciable effect on plate efficiency, but it is also known that a significant slot overload can severely reduce efficiency. Therefore, it is recommended that trays be designed so as not to exceed slot capacity under anticipated maximum flow conditions.

It has been observed that very low slot openings result in vapor flow pulsation. Davies[10] reports this is likely to occur at slot velocities below $3.4(\rho_v)^{1/2}$*. An equivalent criterion has been found in slot opening. As a result, operating slot openings below 0.5 in. are not recommended.

Slot Seal: Some slot seal is necessary to force the vapor to bubble through and contact the liquid. Larger slot seals promote higher plate efficiencies, but at the expense of pressure drop. High slot seals are practical for operations at high pressure, but in the case of vacuum operation the seal must be kept low in order to keep pressure drop within reasonable bounds.

Some designers base their tray design on a selection of *static* seal. This can be misleading, however, because the actual slot seal is dependent on the liquid height over the weir and liquid gradient as well as the static seal. Therefore, it is recommended that the seal be selected on the basis of the *dynamic* slot seal, defined by:

$$h_{ds} = h_{ss} + h_{sw} + \tfrac{1}{2}\Delta \qquad (67)$$

The selection of dynamic slot seal might be based on an analysis of its effect on pressure drop and plate efficiency, as for example with the method of Geddes.[11] However, in lieu of such an evaluation, the following seals have been found reasonable and practical:

Pressure of Operation	Dynamic Slot Seal
Vacuum (50-200 mm Hg abs.)	0.5-1.5 in.
Atmospheric	1.0-2.0 in.
50-100 psig	1.5-3.0 in.
200-500 psig	2.0-4.0 in.

Vapor Distribution: The distribution of vapor among individual caps and rows of caps is very important since it has been shown that poor vapor distribution is one of the principal causes of poor plate efficiencies.[10]

In order to analyze the factors affecting vapor distribution, it is necessary first to determine the effect of vapor load on cap pressure drop. Further, it is most expeditious to begin by analyzing the performance of a single bubble-cap.

For this purpose the standard 4-in. carbon steel bubble-cap† was selected, and, as an example was loaded with benzene vapor at atmospheric pressure. The resulting performance calculated by the equations previously presented is shown in Fig. 23. Here plotted as a function of vapor load per cap are: slot opening, slot load, and cap pressure drop.

It will be noted that the slots of the cap are fully loaded at a vapor flow of 0.77 cfs, and that above this point vapor is blowing under the shroud ring.

Consider now the vapor distribution obtained on a tray with several rows of caps in the limiting case of zero liquid gradient. If these caps were loaded to 100% of the slot capacity, the cap performance would be described by the dotted lines drawn on Fig. 23. Under these conditions, the pressure drop through all caps would be 2.3 in., and the vapor distribution would be perfectly uniform among all rows of caps.

Actually there will always be some liquid gradient; otherwise liquid would not flow across the tray. The

*All nomenclature is defined in Part I, Petroleum Processing, Feb. 1956, pg. 67.

†In the example to follow, the cap chosen departed slightly from the standard cap in Table 4 in that it had rectangular instead of trapezoidal slots. However, this has only a negligible effect on the results.

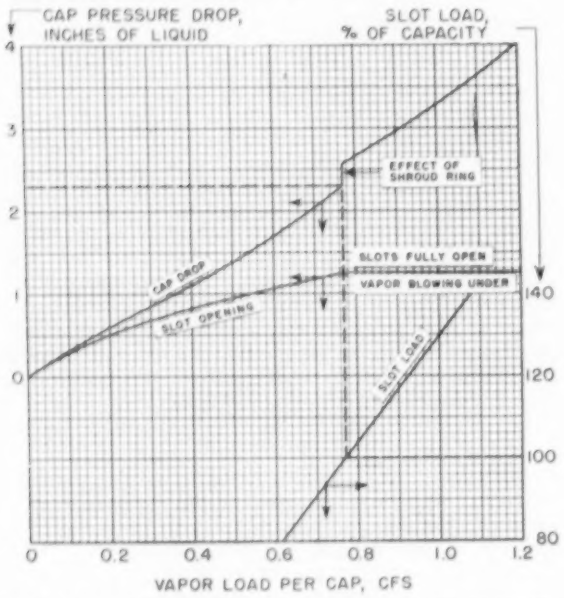


Fig. 23—**EFFECT OF VAPOR LOAD ON SLOT OPENING, SLOT LOAD AND CAP PRESSURE DROP** for 4-in. carbon steel caps in benzene system at atmospheric pressure

liquid gradient and its effect on cap performance is illustrated in Fig. 24 for a tray with bubble-caps of constant skirt height. Because of the varying liquid depth, the vapor flows most easily through the outlet row of caps, and least through the inlet row.

It should be evident that the total tray pressure drops through all rows of bubble-caps are equal. On the other hand, the vapor pressure drop through any one row of caps is described by:

$$h_t = h_c + h_{ss} + h_{ow} + \Delta \qquad (68)$$

where Δ = the liquid gradient from weir to that particular row.

Now, it should be realized that h_t, h_{ss}, *and* h_{ow} are constants for the tray. Therefore, it should be apparent that h_c must vary with Δ, row by row, as shown in Fig. 24.

Since h_c varies by the row, it should then be evident that the vapor load per cap varies from row to row according to the cap performance curves (as in Fig. 23).

Vapor Distribution Ratio: Further study of Fig. 24 should reveal that the effect of liquid gradient should be analyzed not in terms of absolute gradient, but rather as the ratio of liquid gradient to mean cap pressure drop. This factor is called the *vapor distribution ratio*, and is defined by the following equation:

$$R_v = \frac{\Delta}{h_c} \qquad (69)$$

The significance of vapor distribution ratio in tray design was first published by Cicalese, et. al.[15]

The effect of liquid gradient on vapor distribution has been studied over a wide range of vapor distribution ratios. For example, let us analyze the vapor distribution obtained on a tray with a vapor distribution ratio of 0.50. For this purpose the same case and conditions used in Fig. 23 will be employed. The caps are loaded to an *average* cap slot load of 100%, where the average cap pressure drop is 2.3 inches. The liquid gradient is 1.15 in. as shown in Fig. 25.

A mathematical analysis of this diagram should reveal that the cap loads will line out when the shaded triangular areas between the inlet and outlet rows are equal. Under these conditions it will be noted that the vapor load through the inlet row of caps is 84%, whereas the load on the outlet row is 119% of slot capacity.

The above procedure was repeated for vapor distribution ratios of 0.1, 0.2, 1.0, and 2.3, the results of which are shown in Fig. 26. As a vapor distribution ratio increases, the degree of maldistribution also increases. When the vapor distribution ratio reaches 1.0, the inlet row is 62% loaded whereas the outlet row is loaded to 141%. It is shown further, in this case, that when the vapor distribution ratio reaches 2.3, the load on the outlet row reaches 188%, while the inlet row passes no vapor at all.

If the vapor distribution ratio is increased beyond 2.3, liquid will begin to pour down the risers of inlet row of caps. This is called dumping, and has a very serious effect on plate efficiency. In the case of cross-flow trays, it will be evident that any liquid dumping through the inlet row of caps actually bypasses two complete trays.

With high values of vapor distribution ratio there is considerable flow of vapor *across* the tray because the rows of caps with the heaviest vapor loads alternate from tray to tray. Furthermore, this cross-flow of vapor is counter-current to the liquid flow.

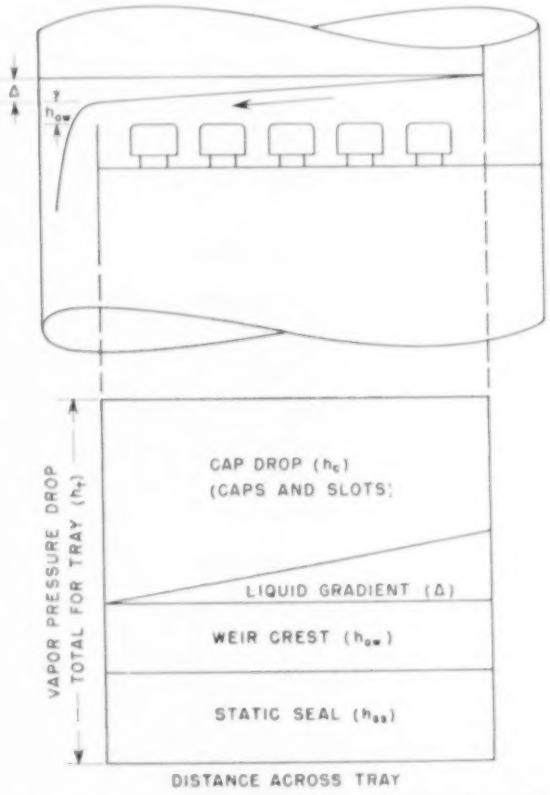


Fig. 24—**EFFECT OF LIQUID GRADIENT ON TRAY DYNAMICS**

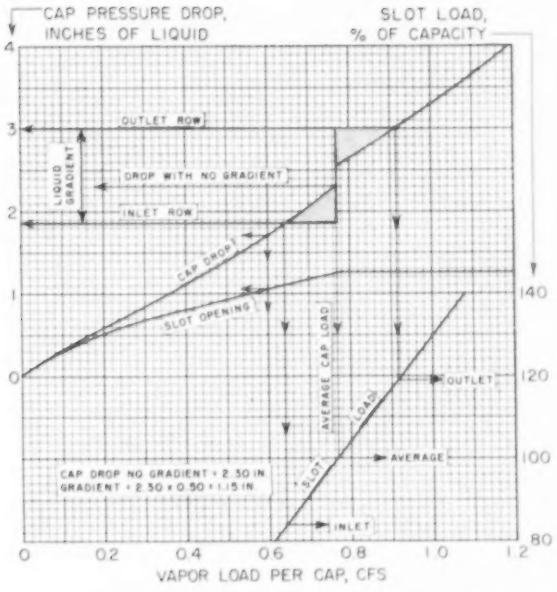


Fig. 25—**EFFECT OF LIQUID GRADIENT ON VAPOR DISTRIBUTION WITH 0.50 VAPOR DISTRIBUTION RATIO** for standard 4-in. carbon steel caps in a benzene system at atmospheric pressure

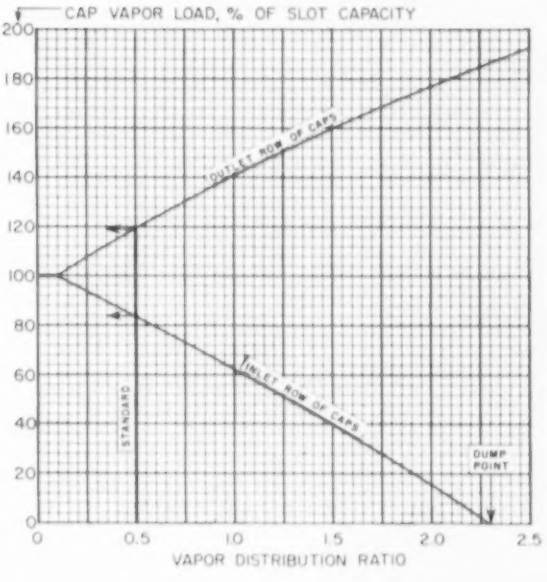


Fig. 26—**RELATIONSHIP BETWEEN VAPOR DISTRIBUTION RATIO AND VAPOR DISTRIBUTION** with standard 4-in. carbon steel caps in a benzene system at atmospheric pressure. Average cap loaded to 100% slop capacity

With a significant amount of maldistribution, particularly if the tray spacings are small, the cross-flow of vapor can reach such an extent that friction between countercurrent streams of vapor and liquid adds to the liquid gradient, resulting in even greater vapor maldistribution, etc.

Photographs of some of these phenomena are published by Good, Hutchinson, and Rousseau.[14]

Davies[10] recommends that the vapor distribution ratio should always be less than 0.6, and normally less than 0.4. Fig. 26 shows that at a vapor distribution ratio of 0.5, the caps in the inlet row are 84% loaded and those in the outlet rows 119%.

The exact effect of this vapor distribution ratio in other cases may be slightly different. However, experience has shown that with vapor distribution ratios exceeding 0.5, the maldistribution of vapor becomes sufficient to impair local efficiencies on the outlet rows and cause objectionable cross-flow of vapor.

Therefore, it is recommended that trays be designed so as not to exceed a vapor distribution ratio of 0.5.

A few comments are necessary in regard to the application of vapor distribution ratio to special cases. One such special case is where the caps are "stepped", that is, installed at more than one level. Here it is advisable to calculate the vapor distribution ratio for all combinations of pairs of rows bordering the stepped sections in order to find the worst vapor distribution ratio on the tray.

An example should help to make this clear. In Fig. 27, a tray is sketched with eight rows of caps including one set of four rows at one level and the other four at another level. This is done in an attempt to match the cap elevations to the liquid gradient. In order to find the maximum vapor distribution ratio on this tray, it will be necessary to calculate the vapor distribution ratio for rows 1 and 4, 1 and 5, 1 and 8, 4 and 5, 4 and 8, and 5 and 8.

It should also be noted that in application of Equation 68 to any particular combination of rows, it is necessary that the *effective* gradient be employed, which is the liquid gradient between the rows in question minus the amount of stepping.

Another special case arises in connection with analysis of vapor distribution ratio for a cascade tray, which is also illustrated in Fig. 27. Here, again, it is necessary to calculate the vapor distribution ratios for all extreme row combinations including the same six combinations as with stepped caps.

However, in this case the *effective* gradient is most conveniently obtained as the difference in dynamic submergences for the rows in question, which includes the static seal, height over weir, and gradient to the particular row.

Liquid Height in Downcomers: The height of liquid in downcomers is important in order to avoid flooding. Reference is made to Fig. 1* in the following description

*See Part I, PETROLEUM PROCESSING, Feb. 1956, pg. 66.

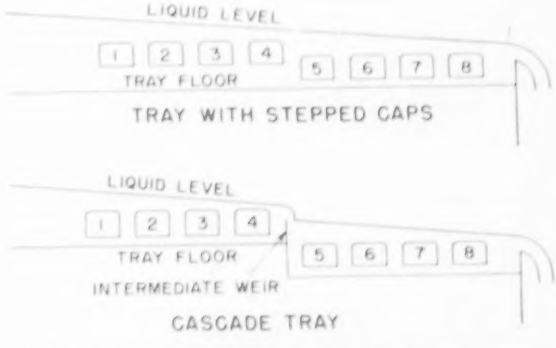


Fig. 27—**APPLICATION OF VAPOR DISTRIBUTION RATIO TO SPECIAL CASES** with tray having stepped caps, and a cascade tray

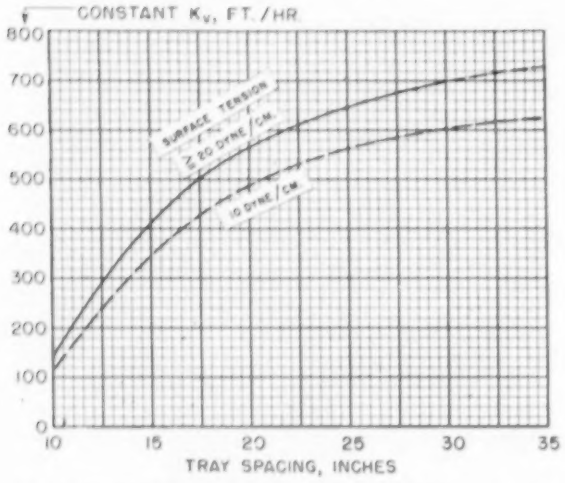


Fig. 28—**SOUDERS AND BROWN CORRELATION** for maximum allowable vapor velocity

of flooding. At low loads there is free space in the upper section of the downcomer. As the load is increased, the height of aerated liquid in the downcomer rises. When the level in the downcomer reaches the top of the weir, the maximum liquid capacity of the downcomer is reached. Any further increase in load causes the liquid to back up from tray to tray, ultimately entirely filling the column with liquid.

This condition is known as flooding. Obviously, a flooded column cannot fractionate efficiently, and trays should be designed so as to insure that flooding will not occur at the maximum anticipated load.

Equation 64 provides a method for calculating the height of liquid in downcomers. However, this equation applies only to the height of clear liquid. Actually, the fluid in the downcomer is in an aerated state and topped with foam. Therefore, it is necessary to make an allowance for foam and aeration. In an attempt to solve this problem, Schutt[21] proposes a laboratory test to determine the degree of foaming. Unfortunately, however, there are no published data on the amount of foam which can be expected.

As a result, it is the practice of most designers to provide an arbitrary amount of free space in the downcomers above the calculated height of clear liquid. For example, Kirkbride[16] writes that "with well designed trays the calculated liquid backup will reach 60 to 80% of the tray spacing before flooding is encountered. Now and then, however, difficulties with vapor entrainment in the liquid downflow will be experienced and flooding will occur at a calculated liquid backup of less than 60% of the tray spacing." Kirkbride then recommends that the tray be designed for a maximum height of clear liquid 50% of the tray spacing. Davies[19] similarly recommends the maximum height of clear liquid be limited to 50% of the tray spacing.

This maximum design limit of 50% has been used successfully in the design of a very large number of commercial fractionators, except that it has been applied to the total downflow height, including the weir. Therefore, this is recommended as the design standard.

Downflow Residence Time: If the downflow residence time is too short, not all of the entrained vapor can disengage from the liquid. Davies[19] reports a study of priming towers in which the maximum calculated residence time in downcomers was 4 seconds. As a result of this study, he recommends a minimum design limit of 5 seconds.

This residence time is based on the total downcomer volume, consisting of the downflow area multiplied by the tray spacing. This is recommended as the standard for downflow residence time.

Liquid Throw Over Weir: The liquid throw over weir must not reach the tower wall (see Fig. 1) or disengaging vapor in the downcomer will not have a pathway to the tray above. Davies[19] gives an equation for minimum downflow width, which is equivalent to a maximum throw of about 60% of the downcomer width as calculated by Equation 39. This seems to be a reasonable allowance, and is recommended as the design standard.

Entrainment: One of the most widely used design methods for the avoidance of entrainment is the correlation of Souders and Brown.[24] This correlation, which was originally proposed as a guide to reasonable vapor velocities, is based on the following equation:

$$G_{max.} = K_v \sqrt{\rho_V (\rho_L - \rho_V)} \qquad (70)$$

This equation results from an application of Stokes' law

Table 5—Analysis of entrainment for bubble-tray tower design

(Souders and Brown correlation used to size columns)

Case	1	2	3
Service	Benzene	Ethylene	Ethylbenzene
Operating conditions			
Pressure, psia	14.7	400	1.0
Temperature, °F.	176	2	136
Reflux ratio (L/V)	0.8	1.5	0.7
Material properties			
Vapor density, lb./cu. ft.	0.168	3.45	0.0165
Liquid density, lb./cu. ft.	43.3	25.5	52.0
Liquid surface tension, dyne/cm.	21	3	25
Tray design			
Tray spacing, in.	18	24	10
Static seal, in.	1.0	2.0	0.0
Tray area, % of tower area	80	80	80
Tray dynamics			
Slot opening, in.	1.0	1.0	1.0
Height over weir, in.	1.0	1.0	1.0
Expected dry plate eff. (E_d)	0.60	0.70	0.90
Souders and Brown correlation			
Constant (ft./hr.)	520	550	150
Max. super. vapor velocity*			
ft./sec.	2.32	0.42	2.34
lb./min.-sq. ft.	23.3	86	2.32
Simkin, et al. correlation			
Operating sup. vap. vel., ft./sec.	2.32	0.42	2.34
Predicted entrainment			
lb./min.-sq. ft.†	1.44	1.31	0.62
mol/mol dry vapor	0.062	0.015	0.27
Colburn equation			
Dry plate efficiency (E_d)	0.60	0.70	0.90
Wet plate efficiency (E_w)	0.58	0.695	0.67
Ratio, wet to dry eff. (E_w/E_d)	0.96	0.99	0.74

*—Based on total column cross section
†—Extrapolated with respect to surface tension

in which the upward force of vapor on entrained liquid drops is equated to the downward force of gravity.

Souders and Brown then proposed a correlation for the constant in the equation, which is reproduced in Fig. 28. This correlation was prepared from data on a number of commercial columns operating under "satisfactory" conditions. This approach to entrainment has been employed by designers for many years in various forms. Another form of this correlation is given in Perry.[18]

Correlations of the Souders and Brown type have been under critical scrutiny for some time. However, only since the publication of the generalized correlation of entrainment by Simkin, Strand, and Olney[23] has it been possible to complete the analysis.

In order to present the nature of the results obtained, three typical cases are singled out as illustrative. The conditions and calculated results for these three cases are presented in Table 5. These cases span the range of operating pressures from 50 mm Hg. absolute to 400 psia, tray spacings from 10 to 24 in., static seals from 0 to 2 in., and dry plate efficiences from 60 to 90%. In each case the maximum allowable vapor velocity was determined by the Souders and Brown correlation. Then the quantity of entrainment under these conditions was calculated by the correlation of Simkin, Strand, and Olney. Finally, the effect of this amount of entrainment on plate efficiency was calculated by the Colburn Equation (65).

The results in Table 5 show that the amount of entrainment per unit vapor varied almost twenty-fold in the three cases cited. It is also apparent that the amount by which this entrainment reduced plate efficiency varied from 1 to 26%. Furthermore, it has been found that entrainment correlations of the type using Equation 70 will in some cases result in entrainments less than 0.01 mols per mol dry vapor! Thus it should be clear that these correlations are no correlations of entrainment.

It is interesting to note that an equation of the same form as Equation 70 can be derived on the basis of factors other than entrainment. For example, consider the derivation of an equation for maximum allowable superficial vapor velocity based on fully loaded slots. Here we begin with Equation 10 for the maximum vapor capacity of rectangular slots:

$$V_m = 0.79\sqrt{H_s\left(\frac{\rho_L - \rho_V}{\rho_V}\right)}A_s \qquad (10)$$

The vapor capacity may then be converted to mass velocity as follows:

$$G_{max.} = \frac{3600 V_m \rho_V}{A_t} \qquad (71)$$

Finally, Equations 10 and 71 may be combined to give the maximum allowable vapor velocity based on fully loaded slots:

$$G_{max.} = \left[2850\left(\frac{A_s}{A_t}\right)\sqrt{H_s}\right]\sqrt{\rho_V(\rho_L - \rho_V)} \qquad (72)$$

It will now be observed that Equation 72 is of the same form as Equation 70, and that the constant now depends upon slot height and proportionate slot area. Thus it should be apparent that analysis of "unsatisfactory" performance purported to be due to entrainment might actually be due to over-loaded slots!

These so-called "entrainment" correlations employing Equation 70 are actually correlations of vapor velocities observed in a number of commercial fractionating columns operating under "satisfactory" conditions. At the time they were proposed they filled a need for a rule-of-thumb to size columns in the absence of sound design methods. However, it is felt that these correlations have now outlived their usefulness.

The only sound approach to entrainment is that proposed by Colburn[7] many years ago, and it is strange that his method has not been more widely accepted. This is probably due to the fact that until recently no generalized correlation of entrainment was available to permit checking the validity of the method. Now, however, this can be done.

The Colburn method is based upon two assumptions. The first is that entrainment follows the equation:

$$e = cN^m \qquad (73)$$

The other assumption is that column cost is proportional to cross-sectional area and number of plates. Based on these two assumptions, Colburn developed a derivation involving determination of minimum column cost and economic optimum entrainment, with the following results:

$$e_{opt.} = \frac{R}{(m-1)E_d} \qquad (74)$$

Based on the limited entrainment data available at that time, Colburn concluded that the value of m is approximately 4. This assumption was checked for a number of cases by application of the Simkin, Strand, and Olney correlation.

For this purpose, the same three cases cited in Table 5 were employed to determine the effect of vapor velocity on entrainment, with the results illustrated in Fig. 29. Here it will be apparent that the slopes of the entrainment curves, plotted on logarithmic coordinants, vary widely with load and tray spacing. However, further study has shown that with tray spacings in the range of 18 to 24 in., and with loads giving an entrainment around 0.1, (the critical region), the slope is in the range of 4 to 5. Therefore, it was concluded that Colburn's slope of 4 is valid for most cases.

The substitution of $m = 4$ in Equation 74 results in:

$$e_{opt.} = \frac{R}{3E_d} \qquad (75)$$

In order to understand the significance of Equation 75 it is helpful to combine this equation with Equation 65:

$$E_m = \frac{E_d}{1 + \frac{eE_d}{R}} \qquad (65)$$

to give:

$$\left(\frac{E_m}{E_d}\right)_{opt.} = \frac{1}{1+3} = 0.75 \qquad (76)$$

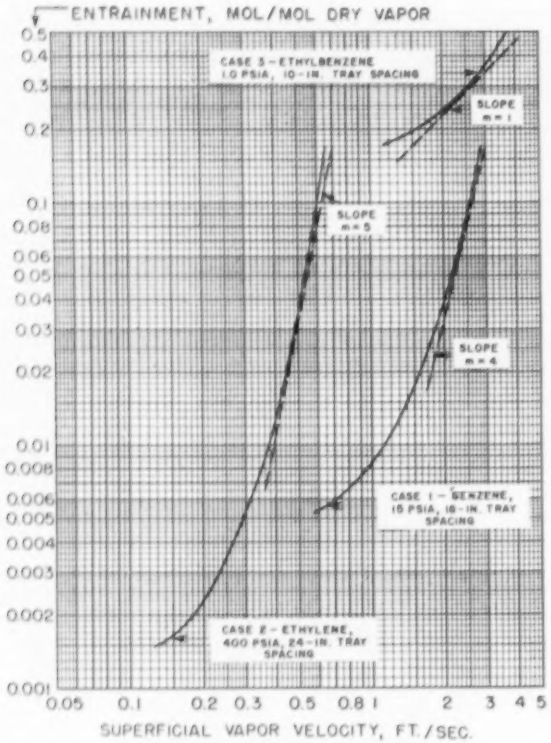


Fig. 29—**EFFECT OF VAPOR LOAD ON ENTRAINMENT** calculated by correlation of Simkin, Strand and Olney

This equation says that at the economic optimum entrainment, the wet plate efficiency is 75% of the dry efficiency. Now, it seems advisable to make some allowance for safety, particularly since entrainment increases so rapidly with velocity. Consequently, it is suggested that a design standard be established such that the wet plate efficiency is a minimum of 90% of the dry efficiency. This is equivalent to:

$$\frac{eE_d}{R} = 0.10 \qquad (77)$$

It is further suggested that the function used in Equation 77 be called the *entrainment quotient*, defined as follows:

$$R_e = \frac{eE_d}{R} \qquad (78)$$

Thus it is recommended that the design standard for entrainment be based on a maximum allowable entrainment quotient of 0.10.

In the use of the entrainment quotient as a design standard, some precautions should be observed. One is the allowance for the effect of entrainment on liquid load. Actually this effect can be more serious than the effect of entrainment on plate efficiency because column flooding can result. Particularly in the case of low dry plate efficiencies, or high reflux ratios, an entrainment quotient of 0.10 will give considerably higher values of e, which might result in exceeding the liquid capacity of the tray. Therefore, it is recommended that, in addition to the limiting entrainment quotient, the actual entrainment be limited to a maximum of 0.10 mol/mol unless an actual check proves that the tray has sufficient liquid capacity to handle higher entrainments.

Another factor which should be borne in mind in connection with entrainment is the limitation of non-volatile impurities in the distillate. This is usually not a controlling factor in setting the maximum limit of entrainment, but it can become so in special cases, particularly when there are a very few plates in the rectification section.

If there is any doubt concerning contamination of product due to entrainment, it is recommended that the degree of contamination be calculated by the equation of Sherwood and Jenny[22]. This equation shows that the amount of contamination in the distillate product increases with (1) increasing concentration of non-volatile impurity in feed, (2) increasing entrainment, (3) decreasing number of plates in the rectification section, and (4) decreasing reflux ratio.

Still another factor to consider in connection with entrainment is the possible carry-over of liquid entrainment to the overhead condenser. This is undesirable because it results in loss of reflux control. However, this entrainment can be almost completely eliminated by providing a disengaging space above the top plate of about twice the tray spacing. In special cases consideration might be given to installation of a mist separator.

Pressure Drop: In tray designs to be employed at atmospheric pressure or above, pressure drop is not usually a limiting factor. In vacuum distillation, however, tray pressure drop becomes very important because of its effect on (1) required reboiler surface, and (2) thermo-chemical reactions involving heat sensitive materials.

Obviously, the limit of pressure drop must be determined for each individual case.

Tray Spacing

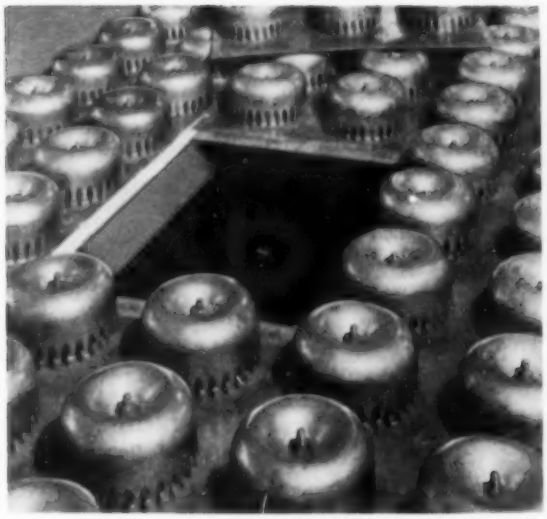
Tray spacings all the way from 6 to 54 in. have been used in commercial columns.

Tray spacing has an important effect on two tray dynamic factors: flooding and entrainment. Under flood-limiting conditions, it should be apparent that there is a reciprocal relationship between tray spacing and tower diameter.

For example, with a design at the flood point, any reduction in tray spacing must be compensated for by an increase in tower diameter in order to avoid flooding. Similarly, under entrainment-limiting conditions there is another reciprocal relationship between tray spacing and tower diameter. In one range of tray spacing flooding is limiting, while in another entrainment is limiting. The break point between these two zones depends on the case under consideration.

It should be apparent, then, that there is a theoretical optimum tray spacing based on tray dynamic considerations which gives minimum column cost. A previous article[2] illustrated how this optimum can be determined and showed for one example that the economic optimum occurred at a tray spacing of about 24 in. However, only one example was studied, and the methods for calculating flooding and entrainment were very crude as compared with the methods herein presented.

Actually, it is usually mechanical factors which decide tray spacing. For example, there must be adequate space between trays at manways. Sufficient manways should be



Courtesy of Badger Manufacturing Co.

TRAY PASSAGEWAY THROUGH REMOVABLE SECTION. Note open slots and liberal skirt height

provided so as to permit reaching any tray without undue hardship. It is recommended that the design provide sufficient manways so as to permit reaching any tray by passing through a maximum of 10 other trays.

If tray manways are removable from either side, which is recommended, the maximum number of trays between column manways is 20. If, however, tray manways are removable from only one side, as may be the case in small columns, it is recommended that column manways be installed at least every 10 trays.

The size of the recommended manway is 20 in. O.D., which is about 19 in. I.D., in order to permit passage of an average man. At these manways, it is recommended that the trays be spaced at 36 in. in order to provide adequate work space.

It is also necessary to provide sufficient space between all other trays so as to facilitate inspection and repairs. In columns 5 ft. and larger in diameter, it is recommended that the tray spacing be a minimum of 24 in. in order to permit workmen to crawl between trays. In columns 4 ft. and below in diameter, it is not necessary to be able to crawl between trays, and a tray spacing of 18 in. can be permitted.

Sometimes consideration of the number of trays in the column may affect the selection of tray spacing. In the case of fractionations requiring a very large number of trays, smaller tray spacings may be considered to avoid splitting the fractionator into two towers.

With fractionators requiring a very small number of trays, on the other hand, consideration may be given to tray spacings greater than 24 in.

Still another special case involves the design of columns to be installed inside existing buildings. Here available head room may fix allowable tray spacing.

Miscellaneous Design Factors

Inlet Weirs: Inlet weirs are specified by some designers to distribute liquid more uniformly across the tray. It is felt, however, that liquid entering a tray from a segmental downcomer is already fairly uniformly distributed without the weir. Also, the first row of bubble-caps serves as a very excellent distributor.

Inlet weirs waste valuable tray area, and are also an undesirable pocket for the collection of sediment. Therefore, inlet weirs are not recommended in any case.

Intermediate Weirs: Intermediate weirs are recommended to reduce the vapor distribution ratio when other measures are insufficient. However, it is important that the intermediate weir be designed to function as a true weir and not submerged.

Therefore, it is necessary that the weir height be greater than the calculated liquid height immediately down-stream.

Reverse-Flow Baffles: Reverse-flow baffles are required in the center of reverse-flow trays. However, it must be realized that the baffle will not function properly unless it is high enough to prevent short-circuiting of liquid and foam.

It is recommended that the height of the reverse-flow baffle be at least twice the highest calculated height of clear liquid on the tray.

Bubble-Cap Clearances: It is desirable that the clearance between bubble-caps and tower wall be as small as possible in order to permit maximum utilization of tray area. However, there is a limit to this clearance because of the interference of tray support rings. It is usually possible to design for a minimum clearance of about 1½ in. to column wall.

Similarly, it is desirable that the clearance between the last row of caps and weirs be as small as possible. However, if this clearance is too close, the vapor bubbling from the slots will blow liquid over the weir and produce an uncontrolled effect on slot submergence. In order to avoid this, it is recommended that the minimum clearance between caps and weirs be 3 in.[10]

Similarly, it is recommended that the minimum clearance between caps and down-flow baffles also be 3 in.

Redistribution Baffles: With uniform cap spacing, it is not possible to locate all caps at the end of rows close to the column wall. Thus, liquid will tend to short-circuit those rows with excessive end clearances. Therefore, it is important to close these gaps by the installation of redistribution baffles, which are recommended at the end of every row where the end space to tower wall exceeds the normal cap spacing by 1 in. The clearance between these baffles and the cap should be equal to the cap spacing. The height of the redistribution baffle should be approximately twice the height of clear liquid to allow for foam.

Many designers overlook the importance of redistribution baffles. However, one will be convinced after calculating the amount of liquid which can short-circuit a row with a large end clearance.

Down-Flow Baffle Seal: Some down-flow baffle seal is necessary to insure that vapor cannot pass up through the downcomer. The amount of baffle seal required on larger columns is greater in order to allow for departures from true levelness of trays. The following down-flow baffle seals (height of weir minus height of baffle) are recommended:

Weir to Baffle Distance, ft.	Baffle Seal, in.
Below 5	0.5
5-10	1.0
Above 10	1.5

Design Tray Deflection: Every tray will deflect under its own weight and the weight of the liquid on the tray. Excessive tray deflection is undesirable because it increases the submergence of the caps in the center of the

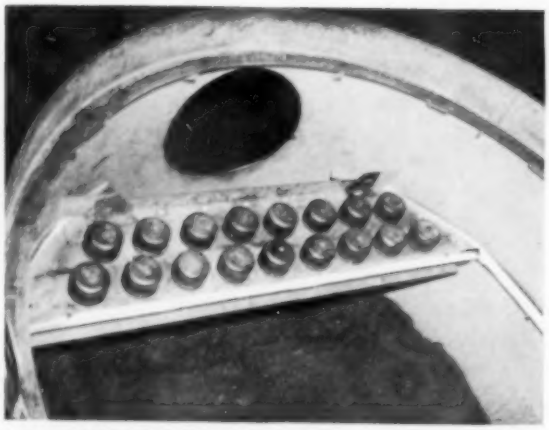
tray thereby contributing to vapor maldistribution. On the other hand, the specification of design deflection should not be too stringent, or it will add to the cost of the tray.

An analysis of vapor distribution ratio will show that a deflection of ⅛ in. will produce a negligible effect on vapor distribution. In the case of large towers, a design deflection of ¼ in. might be permitted.

Drain Holes: The purpose of drain holes is to permit the draining of the liquid holdup from a column after shutdown. If the size of these holes is too small, they will plug with sediment and polymer. However, if they are too large excessive dumping of liquid during normal operation may occur. It is recommended that the drain holes be between ⅜ and ⅝ in. in diameter.

The number and area of drain holes in a tray should be determined on a basis of the desired draining time. Consider, first, the draining of a single tray. In this case, the velocity of flow through the drain holes is given by the orifice equation:

$$u = 0.60\sqrt{2gh/12} \qquad (79)$$



TRAY SECTIONS MUST BE PACKED to prevent leakage

Initially, the head is equal to the height of the weir, which may be substituted in the equation to provide the initial

Table 6—Summary of tray design standards

Materials of Construction	
Type	Sheet metal
Material	Determined by corrosion conditions
Tray Type	
General use	Cross-flow
Low L/V ratio	Reverse-flow
High L/V or large towers	Double-pass
Very high L/V or very large towers	Double-pass, cascade
Downcomers and Weirs	
Downcomer type	Segmental
Downflow baffle	Vertical
Weirs for normal loads	Straight
Weirs for low loads	Notched
Weir adjustment	1-2 in.
Bubble-Caps	
Nominal size for:	
2.5-5 ft. towers	3 in.
4-15 ft. towers	4 in.
10-20 ft. towers	6 in.
Design	See Table 4
Pitch	Equil. triangular, rows normal to flow
Spacing	1-3 in.
Skirt height	0.5-1.5 in.
Fastening	Removable design
Clearances	
Cap to tower wall	1.5 in. minimum
Cap to weir	3 in. minimum
Cap to downflow baffle	3 in. minimum
Tray Dynamics	
Mean slot opening	
Maximum	100% slot height
Minimum	0.5 in.
Mean dynamic slot submergence	
Vacuum operation	0.5-1.5 in.
Atmospheric	1.0-2.0 in.
50-100 psig.	1.5-3.0 in.
200-500 psig.	2.0-4.0 in.
Vapor distribution ratio (Δ/h_c)	0.5 maximum
Tray Dynamics (cont.)	
Height clear liquid in downcomers	50% downflow height, maximum
Downflow residence time	5 seconds, minimum
Liquid throw over weir	60% downflow width, maximum
Entrainment	
As mol/mol dry vapor	0.10 maximum
As entrainment quotient (eE/R)	0.10 maximum
Pressure drop	As limited by process
Tray Spacing	
For towers 2.5-4 ft.	18 in.
For towers 5-20 ft.	24 in.
Miscellaneous Design Factors	
Inlet weirs	Not recommended
Intermediate weirs	Minimum height > height liquid downstream
Reverse-flow baffles	Minimum height twice clear liquid
Redistribution baffles	
Location	All rows where end space is 1-in. > cap spacing
Clearance to caps	Same as cap spacing
Height	Twice height clear liquid
Downflow baffle seal	
Weir to baffle < 5 ft.	0.5 in.
Weir to baffle 5-10 ft.	1.0 in.
Weir to baffle > 10 ft.	1.5 in.
Tray design deflection	⅛ in.
Drain holes	
Size	⅜-⅝ in.
Area	4 sq. in./100 sq. ft. tray area
Leakage	Max fall 1.0 in. from top of weir in 20 min. with drain holes plugged
Construction Tolerances	
Tray levelness	¼-in. maximum
Weir levelness	⅛-in. maximum

drain rate. As time goes on, however, the head reduces, and consequently the draining rate also diminishes. An application of calculus will show that the average drain rate is equal to half the initial rate. Therefore, the drain time for a single tray can be calculated as twice the liquid volume on the tray divided by the initial drain rate.

In the case of a fractionating column, trays are arranged above one another, and every tray must drain through all other trays below it. In this case, it may be shown that the drain time for N_t trays is equal to $(\sqrt{2}/2)N_t$ times the drain time for a single tray. Combining these relations then permits the derivation of an equation for the total drain time of a bubble-tray fractionating column, as follows:

$$T_d = \frac{N_t \sqrt{h_w}}{3A_w} \qquad (80)$$

As a design standard for drain holes, it is recommended that approximately 4 sq. in. of drain holes be provided for every 100 sq. ft. of tray area. This recommendation will result, for example, in the draining of a 50-tray column with a 4-in. weir setting in about 8 hrs.

Usually the majority of the drain holes are placed at the overflow weir, so that any leakage during normal operation will not impair performance. However, at least some of the holes should be provided at potential low spots in order to permit complete draining of the column.

Leakage and Packing: The joints of removable trays will leak under hydrostatic test unless they are packed. Actually, it is possible to have many holes and crevices on the tray and still not show leakage under normal operation due to the differential vapor pressure through the tray. However, if the slots are placed high above the tray and the vapor load is low, the hydrostatic head at the tray floor can exceed the vapor pressure below the tray and leakage during operation is definitely possible.

Liquid leakage is detrimental to plate efficiency because it permits a portion of the liquid to leave the tray without properly contacting vapor. The effect on efficiency depends on the amount of leakage, the place of leakage, and the normal liquid load. In the case of vacuum distillation, where the liquid load per unit tray area is low, leakage can have a serious effect on fractionating efficiency. Even where leakage itself is not critical, many designers include a leakage specification in order to insure the general quality of fitting and workmanship.

A leakage specification in common use calls for a water test in which the level must not fall more than one inch from the top of the weir in 20 minutes with the drain holes plugged.[10] This specification is tight enough to satisfy practically all services but is still attainable if reasonable care is exercised in the design, fabrication, and installation of the tray. However, if leakage is not critical a more liberal specification may be adopted.

In order to meet a tight leakage specification it is necessary to pack all joints. Woven asbestos packing material is commonly used because of its inert chemical properties. However, care must be exercised in the design, selection, and installation of the packing to insure that bits or parts of the packing will not come loose to plug other parts of the equipment and piping.

Construction Tolerances

Any departures from tray levelness will cause vapor maldistribution. The recommended tolerance for tray levelness is a maximum of ¼ in. measured from the lowest to highest points. This amount will produce only a negligible effect on vapor distribution.

The overflow weir must also be level or the liquid will not be distributed uniformly over the tray. The recommended tolerance for weir levelness is ⅛ in. maximum from low to high points.

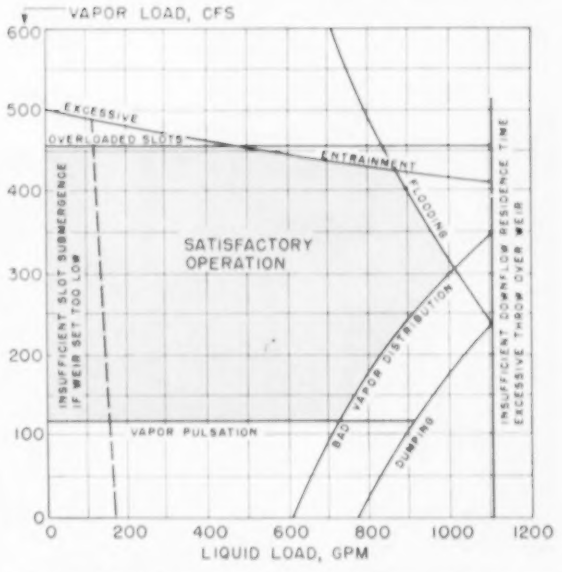


Fig. 30—**QUALITATIVE EFFECT OF LIQUID AND VAPOR LOADS ON BUBBLE-CAP TRAY PERFORMANCE**

Summary

A convenient summary of the tray design standards proposed is given in Table 6.

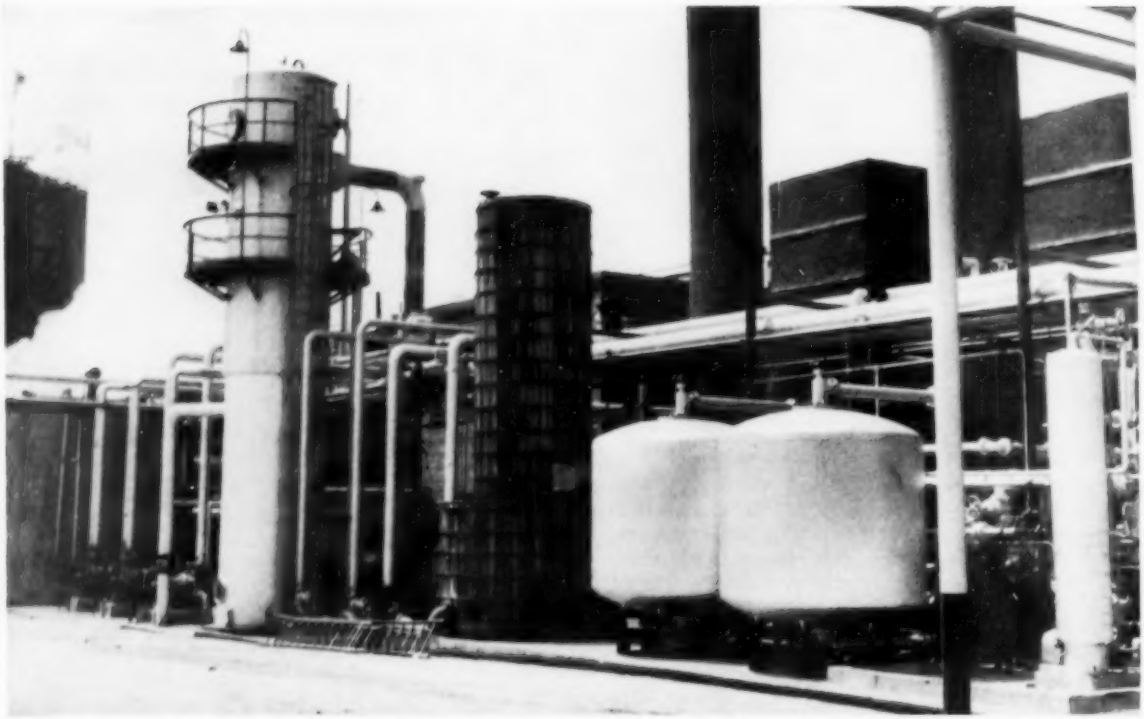
It may be interesting to note the qualitative effect of liquid and vapor loads on bubble-cap tray performance as limited by the tray dynamic standards proposed. This is illustrated by Fig. 30, where the limit of each tray dynamic factor is sketched in for a typical bubble-cap tray.

An area of satisfactory operation is shown surrounded by excessive entrainment, overloaded slots, flooding, insufficient downflow residence time, excessive throw over weir, bad vapor distribution, dumping, and vapor pulsation.

With our present knowledge of bubble-tray dynamics, it is not possible to predict the exact boundaries of the area of satisfactory operation. This is because there have been so few publications of commercial tower performance in which the effect of load on efficiency has been determined over a wide range.

Perhaps the best example of such a publication is that of Brown and Lockhart[11] who studied the effect of load on performance in a 6-ft. diameter gasoline fractionator containing 30 bubble-cap trays. The results, which were plotted as plate efficiency versus load, showed that there is a maximum in the efficiency curve, and also that near-maximum efficiency is maintained over a wide range of loads.

It is hoped that future publications on commercial tower performance will be directed toward defining more clearly the area of satisfactory operation. This would permit even closer design of bubble-cap trays and further savings in capital cost.



BOILER FEEDWATER TREATER is electronically controlled. Shown right to left are: acid day tank and injection pump, automatic switching manifold, zeolite contactors, aerator tower, booster pumps, deaerator tower and feedwater pumps

To cut boiler maintenance

You Can't Beat Good Feedwater

—this well designed system provides it

By J. B. ADAMS, Mechanical Superintendent
Lion Oil Co., El Dorado, Ark.

A HIGHLY efficient zeolite boiler feedwater conditioning system has greatly reduced boiler maintenance at the Lion Oil Co. refinery, El Dorado, Ark.

The system's benefits were graphically demonstrated by a recent boiler inspection. After two years of operation, there were no signs of corrosion, etching, overheating or scale formations in either the drums or tubes. The boilers were placed back in service without any cleaning or repairs other than the normal repacking of valves, checking of relief valves, and servicing of the induced and forced draft fans and drivers.

Though fundamentally a conventional zeolite water treatment system, its operation is completely automatic through the use of the automatic cycle timing device which works in conjunction with the two "poppet" valves and various pressure controls. The arrangement of the instrumentation throughout the entire boiler installation is unique in that it is very simple, yet highly efficient and completely automatic. Unfortunately, however, many boiler operators do not have steam requirements permitting use of this type of control system.

Water Treating System

An outdoor duplex hydrogen zeolite cat-ion exchanger system is used for treating the boiler water. As shown the large picture, the boilers and auxiliary equipment are installed entirely outdoors.

The geographical location of the plant is suitable for the outdoor installation which was constructed with considerably less capital outlay than would have been needed for an indoor installation.

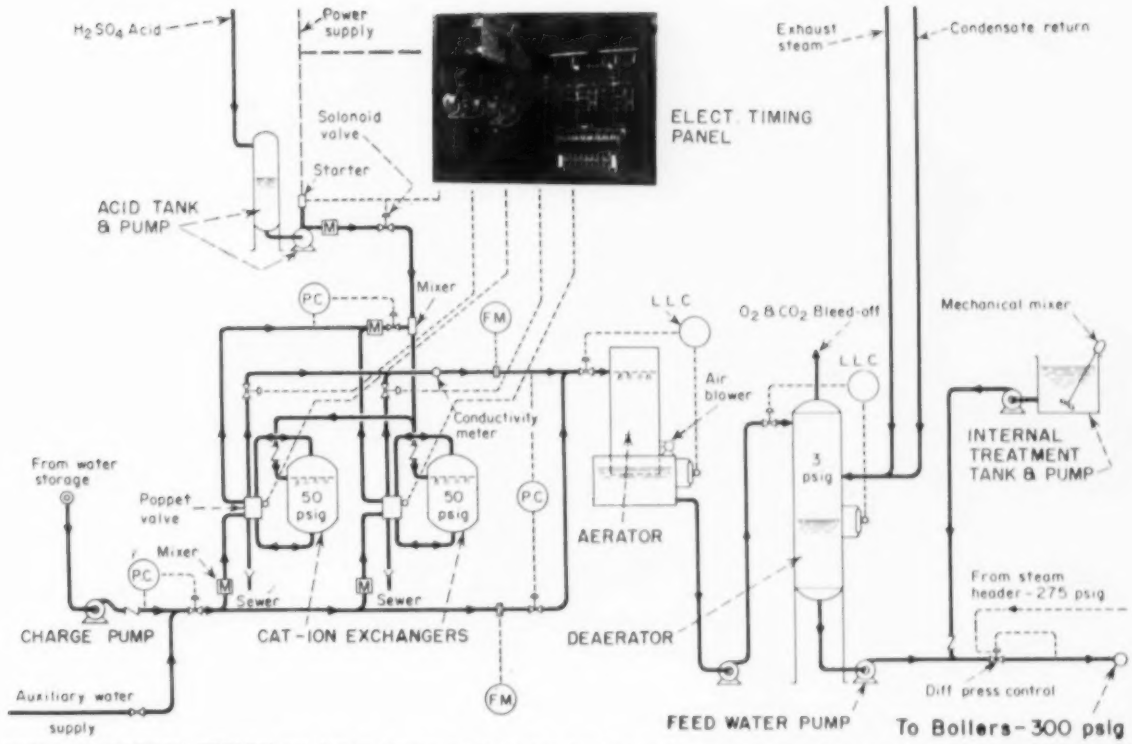
Equipment used in the treating process, other than the cat-ion exchangers, includes the sulfuric acid injection pump and day tank, aerator tower, booster pumps and deaerator tower.

The entire treating cycle, including backwash, sulfuric acid injection and rinsing, is automatically controlled by an electrically operated timing panel located in a weatherproof cabinet adjacent to the switching manifolds—shown in the flow diagram.

Steam Generation System

The treating system furnishes feedwater for two gas-fired integral furnace boilers with a capacity of 100,000 lb./hr. each, and is designed with enough capacity for a third boiler to be added later.

Dry and saturated steam at 275 psig



DUPLEX HYDROGEN ZEOLITE cat-ion exchanger feedwater treater system in successful operation at Lion Oil Co.'s El Dorado Ark. refinery. The automatic cycle timing mechanism shown in the photo is electrically operated and waterproof

is generated principally to power turbine-driven centrifgual compressors and pumps equipped with either surface or barometric condensers. The steam also provides heat for process tower reboilers.

Steam used to drive the larger turbines is superheated to 700°F in a separately gas-fired superheater furnace located in the process area.

Condensate from the surface condenser and reboilers, and low pressure exhaust steam, used for deaerating the feedwater, furnish about 15% of the boiler make-up feedwater. The other 85% is provided from the raw water reservoir via the conditioning unit.

Raw Water Source

Raw water is produced from deep wells at 70°F, and passed through product coolers at the process areas where it is heated to 110°F before being diverted to a 150,000 gal. storage reservoir.

This reservoir was originally of open top construction—conducive to algae growth which caused badly fouled zeolite beds, excessive pressure drops and low exchanger efficiency. This condition was corrected by thoroughly cleaning the reservoir and installing a welded steel roof to prevent further growth of algae. The zeolite beds were effectively cleaned in place by treating with a 5% solution of tri-sodium phosphate.

Treater Operation

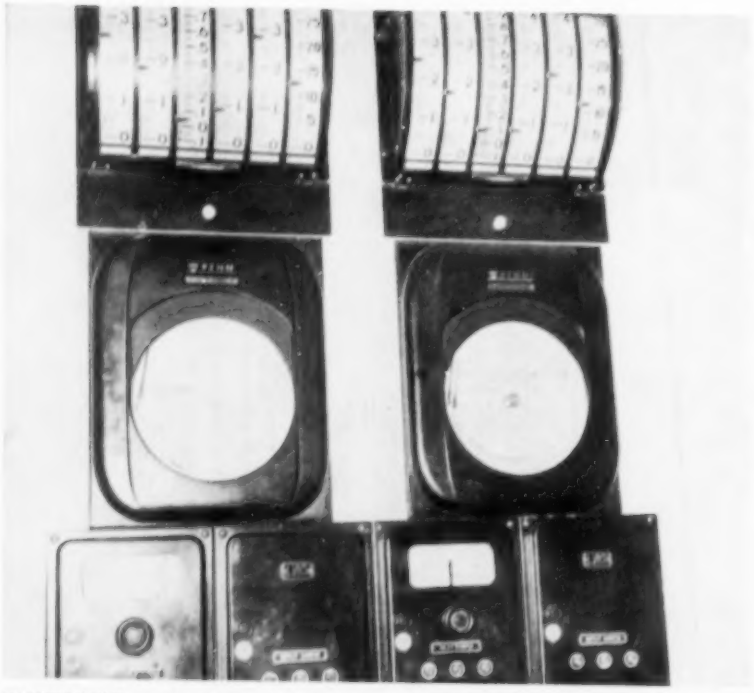
The treater is designed for use with water of low hardness and high alkalinity. In this treater, 60% of the raw water, as shown in the accompanying table, is passed through the zeolite units where the calcium, magnesium and sodium ions are exchanged for hydrogen, and the bicarbonate (alkalinity), sulfate, nitrate and chloride radicals are converted to their respective acids, viz, carbonic (H_2CO_3), sulphuric (H_2SO_4), nitric (HNO_3) and hydrochloric (HCl).

The remaining 40% of the raw water is blended back with the effluent

Typical water analyses through the water treatment system

Cations	Analysis in ppm as:	Raw water	Theoretical water from H-Z unit	Blend of raw and H-Z waters(1)	Degassified water(2)
Calcium (Ca^{++})	$CaCO_3$	5	0	2	2
Magnesium (Mg^{++})	$CaCO_3$	4	0	1	1
Sodium (Na^{+})	$CaCO_3$	244	0	90	90
Hydrogen = FMA (H^{+})	$CaCO_3$	0	63	0	—
Total cations	$CaCO_3$	253	63	93	93
Anions					
Bicarbonate (HCO_3^{-})	$CaCO_3$	190	0	30	30
Carbonate (CO_3^{--})	$CaCO_3$	0	0	0	0
Hydroxide (OH^{-})	$CaCO_3$	0	0	0	0
Sulfate (SO_4^{--})	$CaCO_3$	5	5	5	5
Chloride (Cl^{-})	$CaCO_3$	58	58	58	58
Total anions	$CaCO_3$	253	63	93	93
Total Hardness	$CaCO_3$	9	0	3	3
Methyl Orange Alkalinity	$CaCO_3$	190	0	30	30
Iron, total	Fe	0.1	0	0	0
Carbon Dioxide, free	CO_2	4	171	145	10
Silica	SiO_2	14.8	14.8	14.8	14.8
Turbidity	———	6	nil	nil	nil
pH		8.3	2.8	4.8	6.8

(1) Blended to maintain 1:2 silica-alkalinity ratio
(2) Assume 10 ppm CO_2 leaks



ELECTRONIC automatic control instruments for both boilers are located on common control panel in central control room

to obtain desired alkalinity. Since all of the bicarbonates are converted to carbonic acid, which is very unstable in water solution, they are easily removed by aeration.

Raw water and cycle effluent are blended automatically by a pressure regulating valve, a variable orifice, and a fixed orifice. The pressure ahead of these two orifices is kept equal by the regulating valve so that the flow will be proportional to the size of the orifices. When the variable orifice in the raw water line has been adjusted correctly, the 60-40% ratio will be maintained automatically.

Blended effluent from the exchangers (shown in the table) is sprayed down through an aerating tower into a surge tank. It is brought by booster pumps into the deaerator tower where it is heated by steam contact to 230°F, and the oxygen and carbon dioxide removed.

Treated water is then pumped directly from the deaerator through a differential pressure controller to the feedwater header on the boilers.

Feedwater header pressure is controlled at 25 psig above that of the steam header on the boilers to allow smoother operation of the feedwater regulators, which are of the two-element type, being actuated by both the drum water level and the steam flow. These regulators perform very satisfactorily with a minimum of attention.

Pressures, flows and levels are controlled automatically throughout the entire system. The only attendant required is the boiler fireman. He makes necessary adjustments and checks the exchanger effluent hourly with a conductivity meter.

Water analysis, cycle timing, acid utilization, etc. is supervised by the chief chemist.

Further treatment of boiler feedwater is done by injecting mono-sodium phosphate and tannin to precipitate scale-forming salts which are then removed by continuous blowdown. The total blowdown, including that of mud-drums, amounts to approximately 7% of the total feedwater to the boilers.

Boiler System

The two integral furnace outdoor boilers are of the bent-tube type, consisting of water-cooled walls, floor and roof, tubular air preheaters, combination forced-draft, natural gas and fuel oil burners, and steam turbine-driven forced-draft and induced draft fans.

The boilers are built facing a common two-deck firing platform shown above, from which all appurtenances are readily accessible for convenience in operation and maintenance.

Each boiler has 10,788 sq. ft. of heating surface with a design pressure of 300 psig. The two drums on each boiler are 18 ft. long. Diameter of the steam drum is 48 in., the mud drum, 36 in. The steam drum is equipped with feedwater distribution header, flow baffling and cyclone separators which hold solids carryover to less than 3 ppm.

Boilers are equipped with the latest type electronic automatic control instruments which are mounted on a common panel in the control room which also houses instruments for eleven indoor boilers located in the central boiler house.

All valves and dampers are operated by reversible electric motors, controlled directly from the electronic instruments on the central panel.

The boilers are operated at constant load, constant pressure conditions. Any excess steam above the requirements is released by an automatic back-pressure controller to a lower pressure, and used to supplement process steam in the plant system.

This type of operation has greatly simplified the combustion control instrumentation requirements. At the same time it permits the boilers to operate at an efficiency of approximately 81% at all times, with very few adjustments by the fireman.

Meet the Author

Mr. J. B. Adams, mechanical superintendent, Lion Oil Co., El Dorado, Ark., was born in Union County, Ark., in 1912. He received his B.S. degree in Mechanical Engineering from the University of Arkansas in 1937, joining the Lion Oil Co. immediately thereafter. Mr. Adams is a registered professional engineer in the state of Arkansas, a member of the Arkansas Society of Professional Engineers, the National Society of Professional Engineers, the Ark-La-Tex Mechanical Engineers Society, and is vice-chairman of the Shreveport, La., sub-chapter of the American Society of Mechanical Engineers. During his 18 years with Lion Oil, he has served in practically every department within the refinery, but has been primarily concerned with maintenance, construction, and engineering work.

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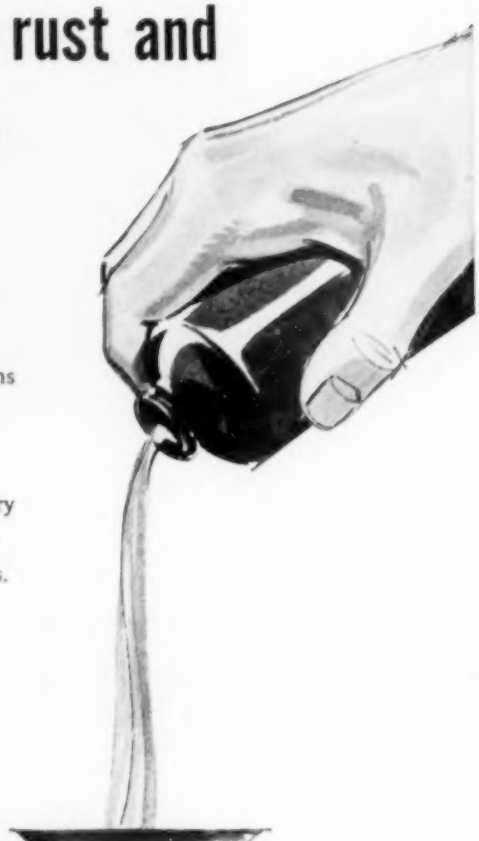

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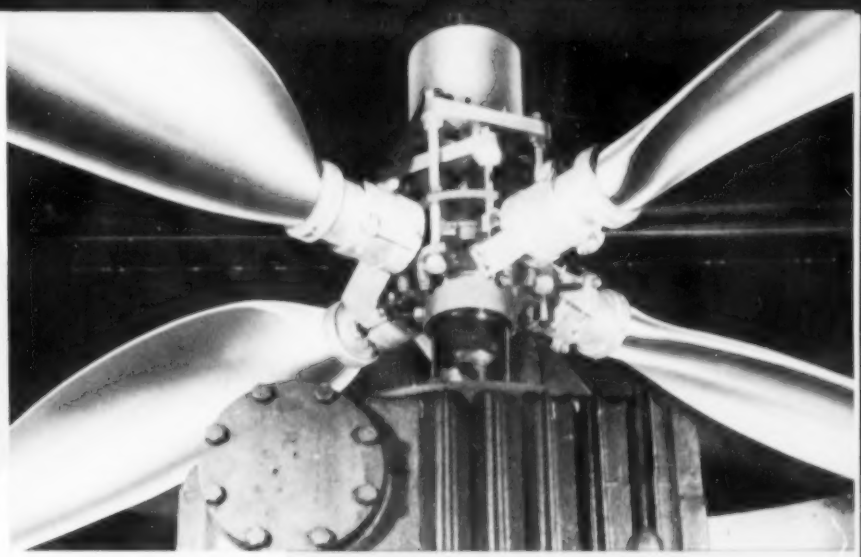

hold fluid outlet temperature to ± 1½° F ...cut power costs by up to 50% with the Hartzell Controllable Pitch Fan

The Hartzell Controllable Pitch Fan meets a long-standing need in the petroleum industry for a precise, relatively fool-proof method of controlling a variable flow of air to maintain predetermined temperatures. These new fans will hold outlet temperature fluctuations to plus or minus 1½° F. when connected to an adequate temperature-sensitive control system. And, while achieving this highly accurate level of control, they consume up to 50% less power than conventional fixed-pitch fans.

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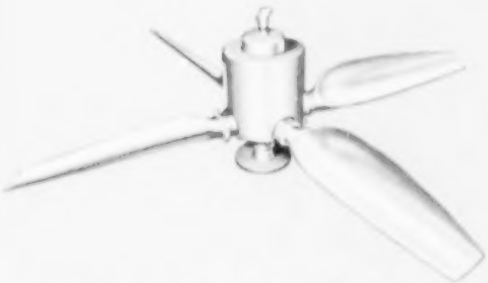
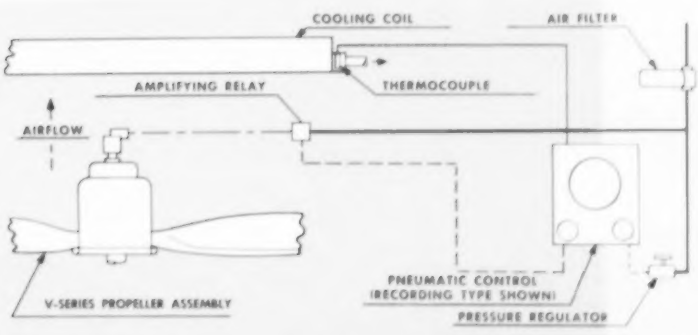
The design of the Hartzell Controllable Pitch Fan is based on the same principal used on the Hartzell constant speed, full feathering propellers which are now used on all light twin engine airplanes. In fact, many of the same parts are used. The ball-bearing and clamp blade retention mechanism has proved an unqualified success in ten years of aviation service. Another carry-over from the aircraft propeller is the exceptionally heavy torque tube which easily withstands the heavy torque and bending loads common to heat exchanger installations.

The Hartzell Controllable Pitch Fan is available in 144", 132" and 120" diameters with Hartzite plastic blades or 120", 103" and 96" diameters with cast aluminum alloy blades.



The photo at the top of the page shows a Hartzell Controllable Pitch Fan with Hartzite plastic blades installed on a speed reducer. Cylinder cover has been removed to show push plate and rods which respond to changes in air pressure in the control system to produce changes in blade pitch. The view immediately above shows an aluminum fan assembly with cylinder cover in position.



Typical Control Diagram—Hartzell Controllable Pitch Fan

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- **See the opposite side of this sheet for information on the petroleum industry's preferred line of adjustable pitch cooling tower and heat exchanger fans.**

Hartzell adjustable-pitch cooling tower and heat exchanger fans practically eliminate problems of fan failure

Hartzite Plastic Adjustable Pitch Fans

Phenolic-impregnated, fabric-base Hartzite plastic offers exceptional resistance to vibration, corrosion and mechanical damage. And if the surface of the blade should be damaged, the interior offers the same high strength and resistance.

Strength and rigidity are insured by the tapered blade design and the use of a heavily-reinforced leading edge. The built-up leading edge also gives the blade a tear-drop cross section which produces top efficiency by smoothing out the flow of air over the blade.

Hubs used with these blades have an extremely high safety factor. All hubs are dynamically balanced and all blades balanced against a master blade. Blade pitch adjustment, to change air delivery, is easily made with a protractor.

SPECIFICATIONS

DIAMETERS: 10′, 11′, 12′, 13′, 14′, 16′, 18′, 20′, 22′

ASSEMBLIES: 2 blade, 3 blade, 4 blade and 6 blade

BLADES: Phenolic-impregnated, fabric-base Hartzite plastic, molded to shape

HUB: Thick steel plate with steel gussets and lower blade clamps welded on; malleable iron upper blade clamp held by 4 or 6 heat-treated bolts

All-Aluminum Adjustable Pitch Fans

Both hub and blades on these fans are sturdy, corrosion-resistant aluminum alloy castings. Blade housings in the hub are threaded to admit threaded blade shanks. Blade pitch adjustment, to meet changing air delivery needs, is made by simply loosening two bolts on each blade socket.

Because all hubs are dynamically balanced and all blades balanced against a master blade, damaged blades can be replaced in the field without destroying balance of the assembly.

SPECIFICATIONS

FAN DIAMETERS: 40″, 44″, 53½″, 60″, 72″, 85″, 96″, 103″, 120″, 132″

ASSEMBLIES: 3 blade, 4 blade and 6 blade

MATERIAL: Cast aluminum alloy

HARTZELL PROPELLER FAN CO.
909 Herrman Ave., Piqua, Ohio

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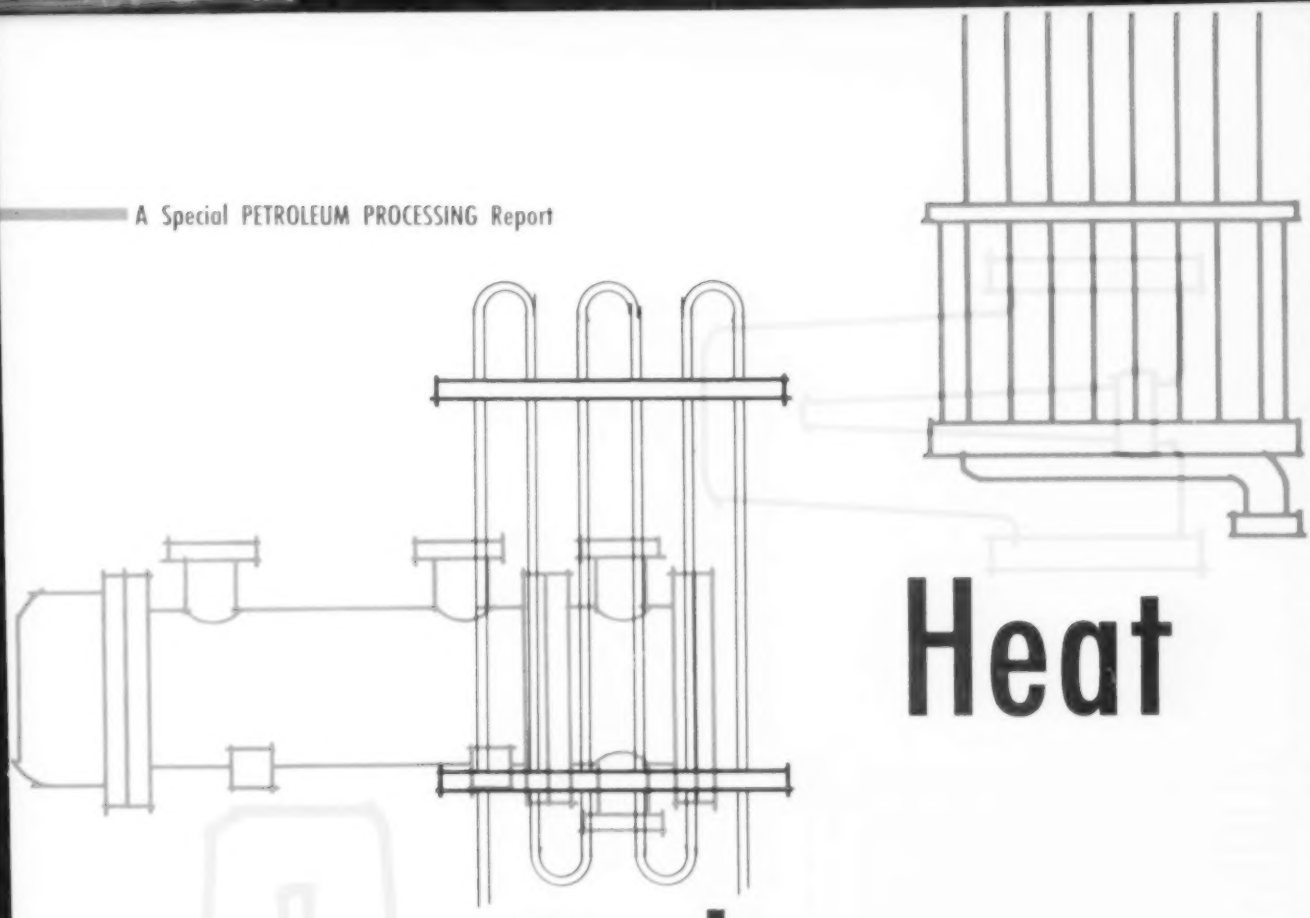

Heat Exchangers

- What they are
- How they are made
- How to design them
- Where they are used
- How they are operated
- How much they cost

By DANIEL A. DONOHUE

Engineer in Charge of Heat Exchangers

Chemical Construction Corp.

Scope

THE name "heat-transfer equipment," as used in this article, includes all those devices which are used for the purpose of transmitting heat from a hot fluid to a colder fluid—under all conditions of temperature and pressure. Examples in both petroleum refineries and petrochemical plants are included.

The pieces of equipment included in this report are largely unfired pressure vessels, such as coolers, heaters, heat exchangers, steam generators, waste-heat boilers, vaporizers, reboilers, chillers, partial condensers, and final condensers. Excluded is flame-fired equipment, such as tube-still heaters and boilers.

In all of the mechanical equipment to be considered the hot and cold media are separated by a solid boundary wall which does two things: (1) keeps the two fluids apart, and (2) permits heat to flow from the hot to the colder fluid. In most cases this boundary is a metal tube or pipe wall, although it can be made of glass or a carbon compound.

In this equipment the most common mechanism by which heat is transferred is forced convection, since both fluids are usually under forced flow. Although heat travels through the boundary wall by conduction, this rate of heat transfer is so great (relative to that of convection) that it is seldom considered in determining the overall coefficient of heat transfer for design. However, if much dirt is deposited inside and outside the boundary wall, conduction does become a very real factor in governing the overall coefficient of heat transfer in the unit.

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Contents

Construction – How they are made, and how construction methods are related to operating conditions page 104

Process Design – How to take into account process requirements and conditions the exchanger must meet page 113

Mechanical Design – How fabrication techniques correlate with theoretical design in actual practice page 122

Typical Duties – What processes require exchangers in today's plants, and what are the limitations page 125

In The Plant – Helpful tips on how to install, operate and maintain exchangers for optimum performance page 129

Costs – Up-to-date data to help you estimate and compare the relative costs of all major types of exchangers page 130

Definition

INDIVIDUAL items of heat-transfer equipment are named after the functions which they perform:

Equipment	Function
Chiller	Cools a fluid to a temperature below that obtainable if water only were used as a coolant. It uses a refrigerant such as ammonia or freon.
Condenser	Condenses a vapor or mixture of vapors, either alone or in the presence of a non-condensable gas.
Partial Condenser	Condenses vapors at a point high enough to provide a temperature difference sufficient to preheat a cold stream of process fluid. This saves heat and eliminates the need for providing a separate preheater (using flame or steam).
Final Condenser	Condenses the vapors to a final storage temperature of approximately 100°F. It uses water-cooling, which means the transferred heat is lost to the process.
Cooler	Cools liquids or gases by means of water.
Exchanger	Performs a double function: (1) heats a cold fluid by (2) using a hot fluid which it cools. None of the transferred heat is lost. (The extent to which the cold fluid picks up the available heat in the hot fluid measures the efficiency of heat transfer.)
Heater	Imparts sensible heat to a liquid or a gas by means of condensing steam or dowtherm.
Reboiler	Connected to the bottom of a fractionating tower, it provides the reboil heat necessary for distillation. The heating medium may be either steam or a hotter process-fluid.
Steam Generator	Generates steam for use elsewhere in the plant by using the available high-level heat in tar or a heavy oil.
Vaporizer	A heater which vaporizes part of the liquid.
Waste-Heat Boiler	Produces steam, similar to steam generators, except that the heating medium is a hot gas produced in a chemical reaction.

These different kinds of heat-transfer equipment are designed mechanically to conform to the rules of the API-ASME and the ASME Codes for Unfired Pressure Vessels, and to the Standards of Tubular Exchanger Manufacturers Association. If operating conditions are beyond the scope of these codes then reliance must be placed on sound engineering design.

Use

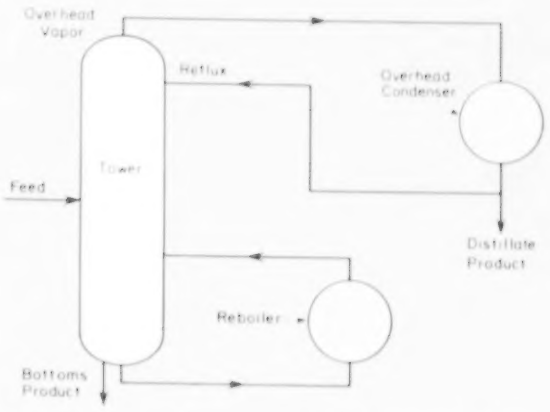


Fig. 1—Distillation process uses a condenser and reboiler, two basic types of heat-transfer equipment

HEAT transfer equipment is used in the basic distillation process, as shown in the accompanying diagram.

The feed stream is introduced to the fractionating tower at its boiling point, where the vapor ascends the tower and is preferentially condensed by the descending liquid. The distillate is vaporized from the top of the tower and passes to the shell-andtube condenser, where it is condensed and cooled down to storage temperature of about 100°F. Part of the distillate is withdrawn as product, the remainder being returned to the tower as reflux.

The relative proportions of distillate and reflux are determined by the operating conditions within the tower; that is, the conditions for which it was designed. The overhead condenser, in condensing all the overhead vapor, removes its latent heat and possibly some sensible heat. The heat removed is thrown away.

In order to compensate for the heat lost in the condenser additional heat must be added to the tower in the reboiler. The temperature of the reboiler at the tower bottom is higher than the temperature of the overhead vapor, due to the temperature variation with the composition of products from top to bottom of the tower.

In continuous operation the feed of a known composition is introduced into the tower and separated into the two components whose composition is pre-determined. The tower is calculated to separate these required components. Thus, in every distillation process, as an inherent and integral part of it, heat exchangers are necessary for the overhead vapor condensation and the tower bottoms reboiling.

In processes other than distillation, heat-transfer equipment is required to perform essential parts of the process —such as cooling, heating or condensing. The size of this equipment depends first upon the magnitude of the process, and second upon the conditions of the available utilities. (Cooling water temperature affects size of a condenser; steam pressure affects size of reboiler.)

In any process where heat is being wasted, an exchanger can be used if the cost of heat saved is enough to pay off within three to five years the cost of installing the exchanger.

Construction

Tubular Sections

Pipe Coil

THE simplest heat-transfer element is a length of steel pipe submerged in a tank of water. The liquid to be cooled (or the vapor to be condensed) flows inside the pipe. A diagram of such a cooler is shown in Fig. 2.

This coil-in-box cooler, of the simplest possible construction, consists of sufficient heat-transfer surface in the form of long steel pipes which are flanged at each end and connected together by means of U-return bends. The pipe is often encased in a creosoted timber box, open at the top. Cooling water is brought over the top of the box and led in pipes to the bottom, at which point it discharges into the box. As it is heated it flows to the top and passes off through an overflow outlet. Pipe diameter and length are worked out for the operating conditions to fit into the space available. The hydrocarbon fluid in the pipe may flow in a single series stream, or in several streams in parallel, whichever is more practicable.

Instead of cooling by submergence in a pool of water (Fig. 3), an alternative method is to use an atmospheric spray in which cooling water is sprayed from overhead nozzles, falling as a film over the surface of the pipes (Fig. 4). After the cooling water has run down over the pipes it is drained from the bottom of the box. (As shown in Figs. 3 and 4, tubular sections—as well as flanged pipe—can be used.)

The heat transfer for water film cooling is far higher than that obtained in submerged sections where the cooling water picks up heat only at a natural convection rate. Water film cooling is enhanced by the evaporation of a small percentage of the water spray into the surrounding atmosphere. But, the installation of a water distributing system for spray cooling is an added cost.

Two disadvantages of submerged pipe coils are: (1) low rate of heat transfer and (2) the relatively large space required per square foot of heat-transfer surface.

Cast-Iron Sections

Cast-iron cooling sections are very much like a pipe-coil cooler with two exceptions. One, cast iron is resistant to salt water and certain chemicals—unlike steel pipe; two, cast-iron sections can be made with integral internal ribs and swirler fins that will break up viscous flow.

Tubular Open Sections

Compared to pipe coils and cast-iron sections, tubular sections require less than half the space and have fewer connections. In some designs, the tubes are set into headers with an initial bow to permit free expansion as they heat up. (See Fig. 5 and 6.) Tube flexure during expansion breaks off accumulated scale.

If the tubes are rolled into cast-iron or steel headers (as shown in Fig. 7) the red-brass tubes may be replaced by removing the bronze plugs, which are lined up with the tubes at the far side of the headers. Tubular sections often operate at the bottom of a cooling tower since their cost is less than comparable shell-and-tube exchangers.

Double Pipe

Unlike the units described so far, the double pipe unit separates the cooling fluid from the atmosphere, and allows the heat-transfer element (pipe) to be surrounded by a faster moving coolant. This double pipe (Fig. 8) provides counterflow, with true counterflow temperature differences—a desirable feature when the temperature ranges of the hot and cold media overlap.

Any differences in expansion between the inner and outer pipes are taken up by the packing at one end. For very small amounts of heat transfer the double pipe costs less than a shell-and-tube exchanger. But for an appreciable amount of heat transfer the double pipe is too bulky and expensive. (A 20-ft. length of 1½-in. I.P.S.-pipe provides only 10 sq. ft. of external, heat-transfer surface.)

Shell-and-Tube Exchangers

A shell-and-tube exchanger is normally composed of four parts: a tube bundle; a shell enclosing the tube bundle; a stationary head; and a return head. In a special type, the floating-head design, the structure of the return head is more complex and consists of three parts: floating-head cover, backing ring and shell cover.

In all shell-and-tube exchangers the tube bundle is made up of a number of tubes contained within a circular cross

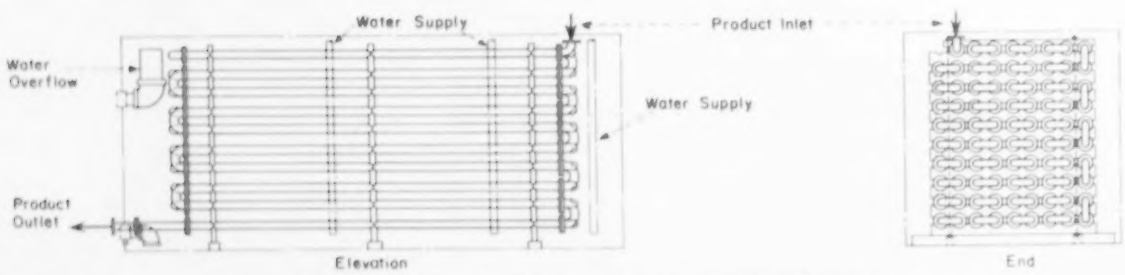


Fig. 2—Pipe coil is the simplest type of heat-transfer equipment

Courtesy of Griscom-Russell Co.

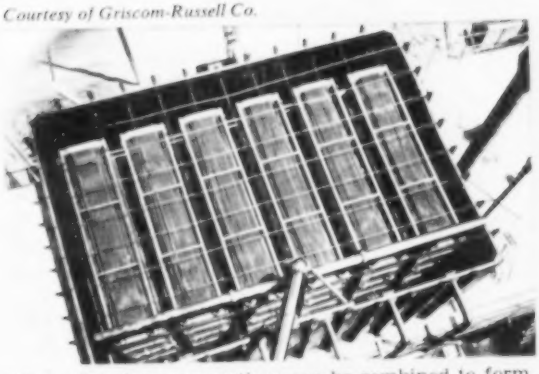


Fig. 3—Tubular open sections can be combined to form a submerged coil

Courtesy of Griscom-Russell Co.

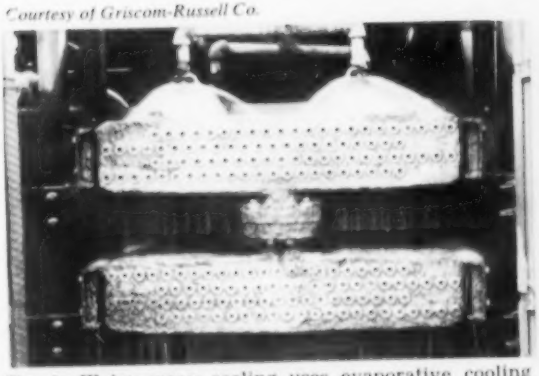


Fig. 4—Water-spray cooling uses evaporative cooling effect

Courtesy of Griscom-Russell Co.

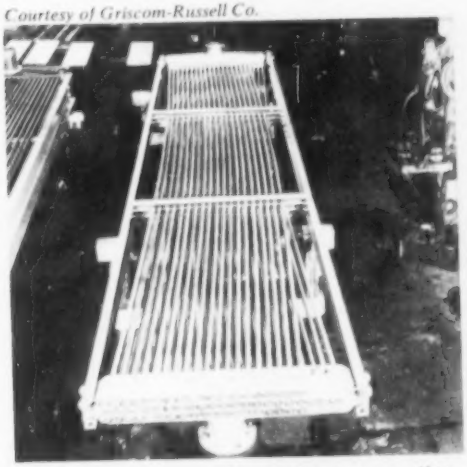


Fig. 5—Tubes in a cold tubular-open-section bow about 3½-in.

Courtesy of Griscom-Russell Co.

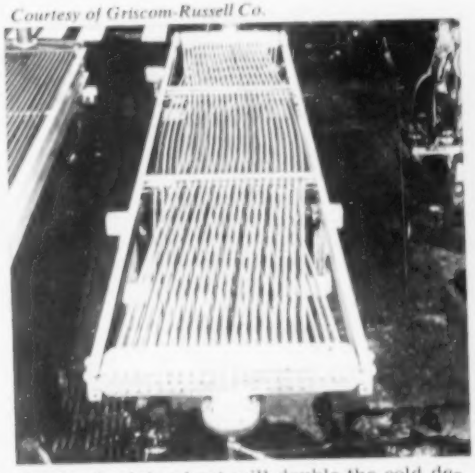


Fig. 6—Applying heat will double the cold deflection, and shed scale

Courtesy of Griscom-Russell Co.

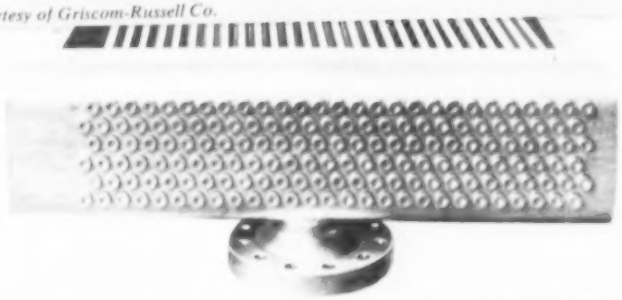


Fig. 7—Bronze plugs, lined up with the tubes, permit tube removal

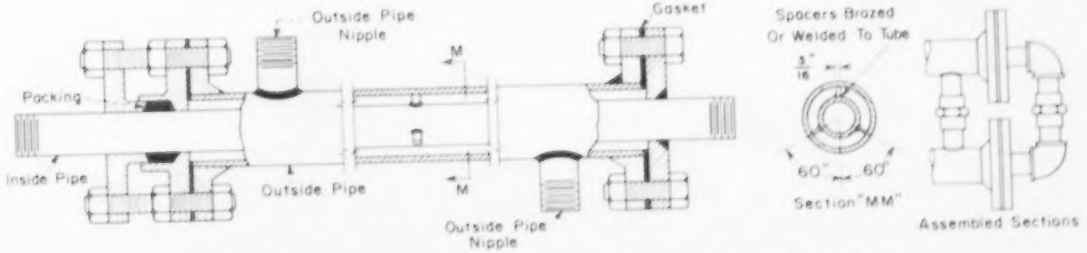


Fig. 8—The double-pipe unit provides true counterflow conditions

section. They are normally rolled at each end into circular tubesheets. Baffles spaced at suitable locations along the tube length direct fluid flow as desired.

As a means of classifying these exchangers it is possible to separate them into three component parts: stationary head, shell and return head. The baffling of the tube bundle is included in the shell section. Using this method of component parts Fig. 9 illustrates 5 types of stationary head, Fig. 10 shows 16 styles of shell and baffles, and Fig. 11 shows 12 different styles of return head and cover. These parts may be combined many ways.

Although these elements do not cover every possible variation in construction they do include all major types. Any variation therefrom will be only minor. Type of construction can be specified by combining the index numbers and letters which identify each part. The fixed-tubesheet design shown in Fig. 12 is designated as 1A1 and the floating-head design shown in Fig. 17 as 4C9. The first number identifies the stationary head, the letter identifies the shell and the last number refers to the return head.

In Fig. 11 the inside diameter of the shell is designated as ID and the diameter of the boundary circle (inside which all tubes must fall) is indicated as OTL (outer tube limit). For mechanical design of a shell-and-tube heat exchanger the starting point is the inside diameter of the shell. The style of return head employed decides the OTL. Thus, in a given size shell, the maximum available heat-transfer surface is related to the mechanical construction of the return head.

Fixed Tubesheet

This type of shell-and-tube exchanger consists of a number of tubes, rolled at each end into circular tubesheets and arranged in a circular cross-section. The tube bundle is completely enclosed within a cylindrical shell.

The simplest type of construction is shown in Fig. 12. In this type the tubes are rolled into the tubesheets and these, together with the baffles and tie rods, form the tube bundle. The shell enclosing the tube bundle is welded to the inner faces of the tubesheets. Cylinders of the same diameter as the shell extend far enough to accommodate the bonnet nozzles. Elliptical caps are welded to these extensions.

It is readily seen that neither the inside nor the outside of the tube is accessible in this type of construction, as both the shell and bonnet are welded to the tubesheet. The unit cannot be cleaned either manually or mechanically. It can be cleaned only by flushing with steam or a chemical solvent.

Another limitation of this type of construction is that the shell, tubesheet and cover must be of material that can be welded together. Brass tubesheets for corrosion resistance, with steel shells and covers, would not be possible—only all steel parts.

Another type of fixed-tubesheet construction, shown in Fig. 13, does allow inspecting and cleaning the inside of the tubes. In place of the welded elliptical caps, flat cover plates are bolted to flanges which are welded to the channel barrels. Unbolting the cover plates allows access to the tubes.

But in both of these types of fixed-tubesheet exchangers, there is no provision for differential thermal expansion. This expansion, which will occur if the temperatures of the two media are only 200°F. apart, may be compensated for by inserting an expansion joint in the shell (Fig. 10-B). This allows the shell to expand with elongation of the tubes.

Fig. 9 — Types of Stationary Heads

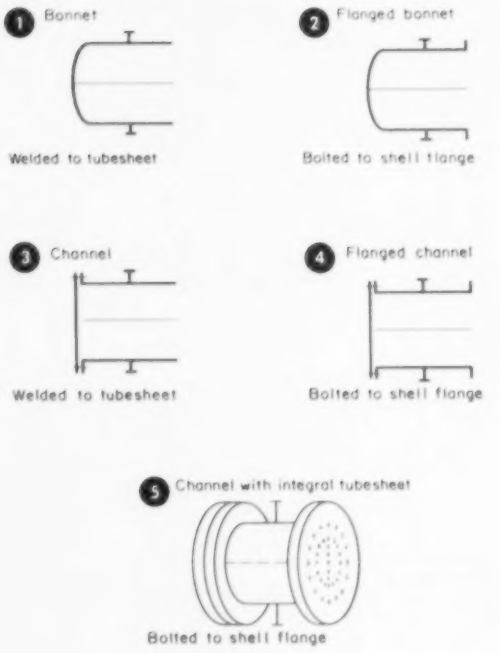


Fig. 11 — Types of Return Heads and Covers

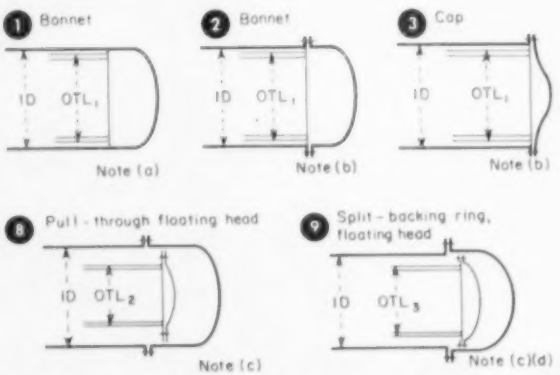


Fig. 11 Note (a) Welded to stationary tubesheet. (b) Flanged and bolted to stationary tubesheet. (c) Shell cover bolted to shell

Fig. 10 — Types of Shells and Baffles

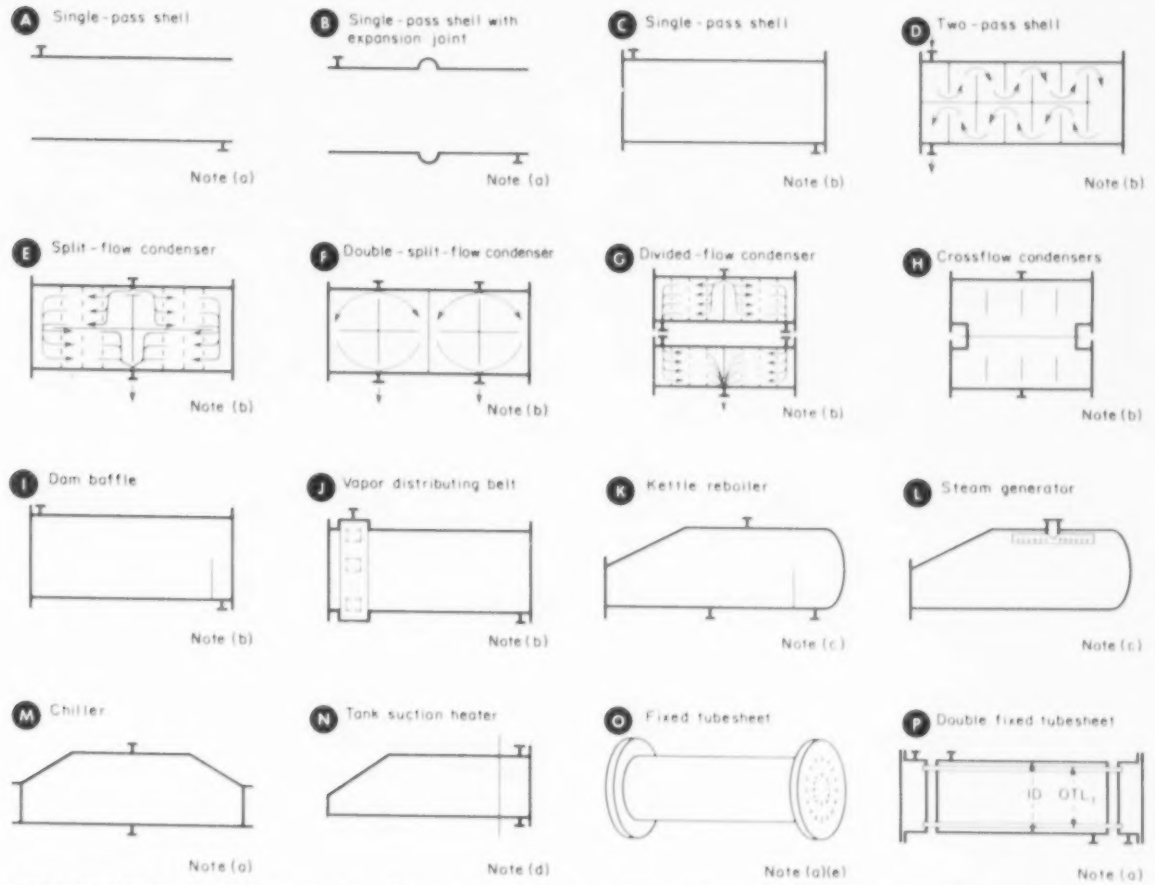
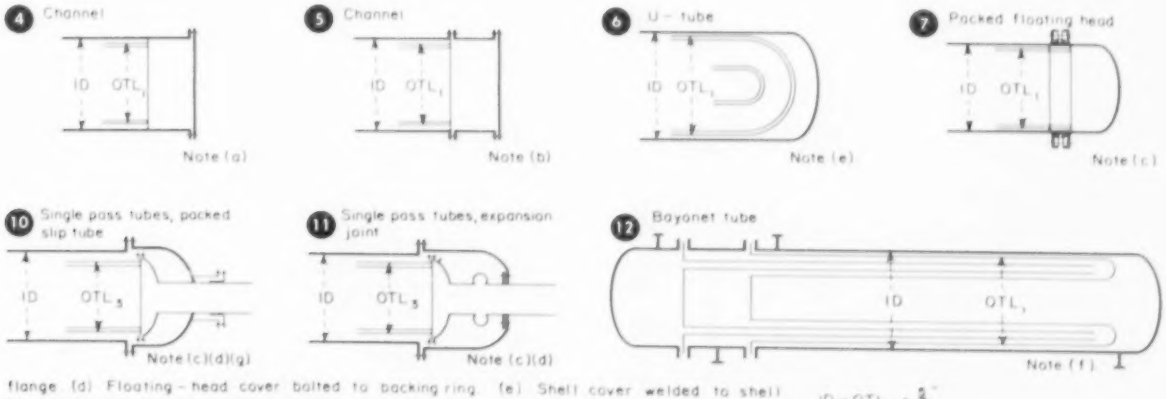


Fig. 10 Note (a) Fixed tubesheet construction. Each end of shell welded to a stationary tubesheet. (b) Shells flanged at each end. Left flange bolts to stationary head, right flange bolts to shell-cover flange. (c) Flanged opening at left for tube bundle. Shell cover welded to shell. (d) Extra shell flange for bolting to tank. (e) Tubesheets serve as shell flanges.



flange. (d) Floating-head cover bolted to backing ring. (e) Shell cover welded to shell. (f) Requires 2 channel compartments. (g) Sealed by externally-packed gland.

$ID - OTL_1 = \frac{3}{8}"$

$ID - OTL_2 = 3\frac{1}{2} - 4\frac{1}{2}"$

$ID - OTL_3 = 1\frac{1}{4} - 1\frac{3}{4}"$

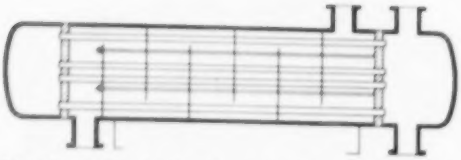


Fig. 12—A fixed tube sheet unit of simple construction can be cleaned only by flushing

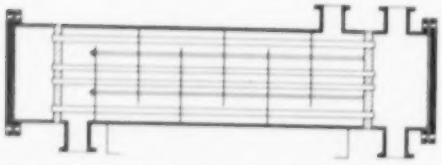


Fig. 13—A fixed tube sheet unit with bolted cover plates allows inspection and cleaning of the inside of tubes

Fig. 14—U-tube construction uses only one tube sheet, and permits inspection of the outside of tubes only

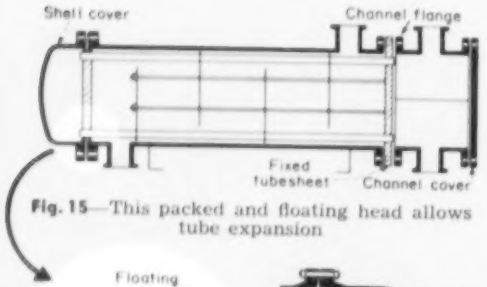


Fig. 15—This packed and floating head allows tube expansion

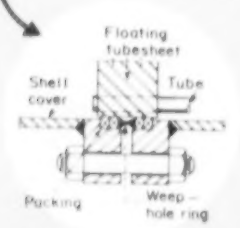


Fig. 15—Detailed view of floating tubesheet lantern-ring

Fig. 16—For higher pressures a cover is placed over the floating head

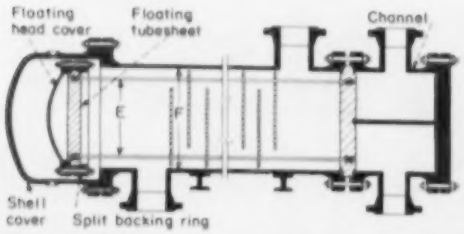


Fig. 17—A split backing ring on the floating-head cover reduces clearance between shell and tube bundle

To prevent possible contamination due to leakage from one fluid stream to another, double tubesheets are used at each end of an exchanger. Due to repeated thermal stress a tube may loosen in the tubesheet hole. With fluid of higher pressure in the tube, leakage from the channel might contaminate the shell fluid and create a serious hazard. To prevent this, the space between the double tubesheets is usually left open to the atmosphere, so that leaking fluid would seek that way out rather than force its way into the pressure section of the shell. Thus this type of construction offers positive protection against mingling of the two fluids (Fig. 10-P).

U-Tube

U-tube construction (Fig. 14) offers several advantages over fixed tubesheets. Both the shell and the bonnet are removable from the stationary tubesheet, thus making inspection of the outer tube surfaces possible. The tubes are also free to expand due to their "hairpin" shape. The tube bundle fits very close to the inside of the shell (within 1/8 in.), for the only spaces needed beyond the tubes are the baffle ligaments surrounding the tubes and the clearance between baffle and shell. This allows fuller utilization of space within the shell.

However, U-tubes are used only for very clean fluids, and cannot be used when fouling inside the tubes is expected. Common uses are for condensing steam inside the tubes, or boiling freon or ammonia. Since U-tubes do not require internal tube cleaning, a bonnet can be used at the stationary end, which offers a savings over the more expensive channel with flange and bolted-on cover.

Floating Head (with removable tube bundle)

Packed, Floating Head

This type of heat exchanger (Fig. 15) has a tubesheet that is free to move back and forth in response to temperature changes. A head is formed by the shell cover and the floating tubesheet. The insides of the tubes are made accessible for cleaning by unbolting and removing both the shell cover and the channel cover. To remove the tube bundle from the shell, the bolting is removed from channel flange, fixed tubesheet, and shell flange. Then the tube bundle is withdrawn.

The shell fluid and tube fluid are separated by a partly hollow, circular lantern-ring that fits around the floating tubesheet, as shown in the detailed view. This lantern ring is packed on each side in order to seal the two fluids. Leakage, if any, passes through weep holes in the lantern-ring where it is visible. This style of construction requires a thick floating tubesheet because it must include the width of the packing and lantern ring—plus an allowance for expansion.

Although the packed, floating head construction is designed to operate at 75 to 150 psi, it is not used in oil refineries due to possible leaking of hydrocarbon oil through the weep holes.

Pull-Through, Floating Head

For the packed, floating-head construction just described, it was found that the strength of the floating-head closure was limited to about 150 psi. In order to handle greater pressures a dished, floating-head cover is bolted to the floating tubesheet, shown in Fig. 16. This closure is good for pressures up to 900 psi.

The necessary large clearance of this type, between the shell and the tube bundle, is most undesirable when fluids are being heated or cooled. The flow will bypass the tube bundle since it prefers a path through this open annulus

to that through the relatively small area in the tube bundle between the tubes.

This large clearance is necessary since a gasket lies within the bolt circle. In order that the tube bundle be removable from the shell, the outside diameter (D) of the floating tubesheet must be only 1/32nd-in. less than the inside diameter of the shell (F). Since the outside diameter of the floating tubesheet is set in this manner then, the diameter (E) of the tube bundle is the difference between dimension D and the space required for bolt and gasket at each side of the tube-bundle cross section. F minus E will vary with shell diameter and operating pressure, within the range 3-4½-in.

In order to withdraw the tube bundle from the shell it is necessary only to unbolt the channel from the shell and pull the tube bundle through the channel end of the unit; neither the shell cover nor the floating-head cover need be removed to accomplish this.

Split Backing Ring

In order to reduce the large, undesirable clearance between the shell and the tube bundle, which is characteristic of pull-through floating head construction, the split-backing-ring style of floating tubesheet, shown in Fig. 17, was designed. This design varies from the preceding one in that the floating tubesheet does not carry the bolting for the floating-head cover. It is carried instead by the split backing ring, which comes in two halves and is removable from the floating tubesheet before the tube bundle is withdrawn through the other end of the shell.

Although the floating tubesheet does not carry the bolts it does carry the gasket. For this reason twice the ⅝-in. gasket width, plus clearances, must be provided between the tube circle diameter (E) and the inside shell diameter (F). F minus E varies with the shell diameter from 1¼ to 1¾-in. With this type of floating-head construction the clearance between the tube bundle and shell is never less than about 1¼-in. Thus it reduces the clearance to less than half that required with pull through, floating-head construction.

This unit is dismantled at the floating-head end by: (1) unbolting the shell cover from the shell and (2) unbolting the floating-head cover and split-backing ring from the floating tubesheet. The tube bundle is withdrawn from the other end of the shell after the channel has been removed.

Unlike the pull-through floating head, the split-backing-ring style requires that the floating-head cover be removed before the tube bundle can be pulled from the shell.

Inserted Tube Bundle

For heating fuel oil or tar held in storage, a suction heater mounted within the storage tank itself (of the type shown in Fig. 10-N) is used. In this operation the pressure head causing flow is the height of liquid in the tank, of which a minimum of 4 ft. is necessary. The tube bundle is enclosed within a separate shell in order to heat only the oil that is being withdrawn for use. With other applications of tube bundles inserted into pressure vessels or storage tanks, no shell is used to enclose the tube bundle.

The tube bundle is inserted in the flanged opening of the vessel and the channel or bonnet is then bolted to this flange, with the stationary tubesheet located between the two flanges. The return end is preferably a U-tube, unless straight tubes are required for cleaning. In this event the pull-through-floating-head construction is employed, having its dished cover bolted to the floating tubesheet. Such tube bundles eliminate the cost of the shell and its cover.

In vacuum-tower distillation where the operating pressure is low—with a permissible pressure drop on the vapor stream limited to 3-5 millimeters of mercury—condenser tube bundles are sometimes inserted at the top of the tower. This eliminates vapor travel through a separate pipe line and condenser shell.

Types of Shell Baffling

If a shell-and-tube exchanger were built without cross baffles the shell fluid, after entering the inlet nozzle and distributing itself across the tube bundle, would flow parallel to the tubes throughout most of their length before discharging from the outlet nozzle. Miniature models have been built and experimentally tested for this style of flow path. However, mechanical requirements dictate that each tube must be supported from sagging at a maximum distance of 52 in. for ¾-in. O.D. tubes. Since only half the tubes can be supported at one time it means that semi-support plates are located every 26 in. along the tube length. These semi-support plates actually are segmental baffles. Therefore, if the tube length is greater than 52 in., there can be no such thing as an unbaffled shell.

An early form of baffle was the orifice baffle which covers the full circular cross section inside the shell, and through which all of the tubes in the bundle pass. Tube holes are drilled larger (1/32 to ⅛-in.) than the tube diameter, with 1/16 in. as the most common increase. It is through the annular area between each tube and tube hole that the fluid must pass, as illustrated in Fig. 18. Between the baffles, flow is parallel to the tube length through a maximum flow area; at the baffles the restricted orifice area causes the fluid to squirt through these openings, producing an increase in coefficient of heat transfer and a pressure drop. It will readily be appreciated that this style of baffling may be used only with absolutely clean fluids because of the small clearance of only 1/32-⅛-in. between tube and baffle hole.

If a fluid carries sediment in suspension these orifices filter it out, causing the pressure drop to rise so high that it becomes necessary to shut down the unit for cleaning. Orifice baffles are spaced as closely as ½-in. apart. Because many oil products are susceptible to fouling, orifice baffles are not used in refineries.

Another form of cross baffling is the disk-and-doughnut style shown in Fig. 19. The doughnut baffle is a full circular plate from which a circular hole has been cut out at its center; it is followed by the disk baffle which is a solid circle located at the center of the tube bundle, larger than the circle cut from the doughnut baffle. Flow passes through the center of the doughnut baffle and fans out radially as it flows across the tube bundle until it passes the edge of the disk; there it reverses direction to again cross the tube bundle while contracting radially, and passes through the opening of the next doughnut baffle. It should be noted that the path of flow is smooth, rounded and symmetrical.

When a circle is cut inside a tube bundle, in which the tubes are laid out on a regular spacing, the circle does not intersect all tubes at their centers, which actually produces a baffle with a jagged edge. In practice, disk-and-doughnut baffles are not often used.

Another type of cross baffling is the segmental baffle which is simply a circle from which a segment has been cut out, as shown in Fig. 20. The cutout area, which is the area of the segment less the cross-sectional area of the tubes passing through it, may vary from 20-45% of the cross-sectional area of the shell less the cross-sectional area of all the tubes. This baffle edge is vertical for con-

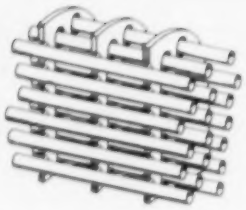


Fig. 18—Baffles with annular orifices create a pressure drop and turbulence in the shell fluid

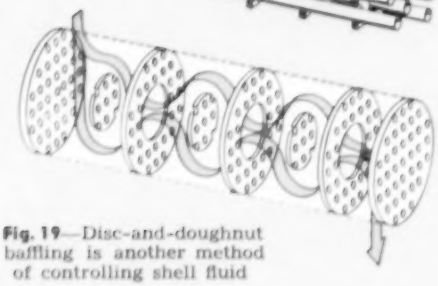


Fig. 19—Disc-and-doughnut baffling is another method of controlling shell fluid

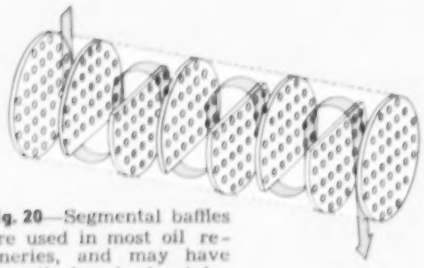


Fig. 20—Segmental baffles are used in most oil refineries, and may have vertical or horizontal edge-arrangement

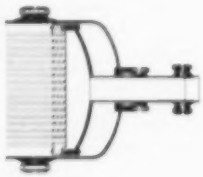


Fig. 21—Packed slip-tube-joint is used on single-pass tube units

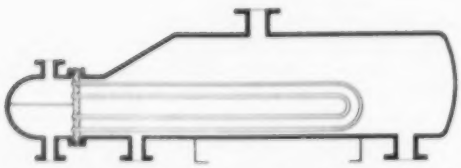


Fig. 22—Kettle-type reboiler with U-tubes is used when the heating medium is steam

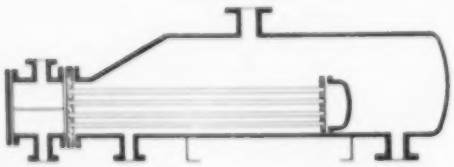


Fig. 23—Kettle-type reboiler with straight tubes allows inspection and cleaning of the inside of the tubes

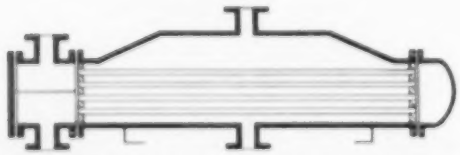


Fig. 24—Fluid inside the tubes of a chiller is cooled by evaporation of the shell refrigerant

densers, vaporizers and fouling liquids.

In a condenser the condensate must be able to drain freely from the shell; a horizontal baffle edge will dam up the condensate whereas the vertical edge permits free drainage. Similarly, when vaporization occurs the vapor must have an unobstructed path in order to emerge from the shell. A horizontal baffle edge will pocket the vapor while the vertical edge permits the vapor to issue freely from the shell. If fouling liquids deposit sediment in passing through the shell baffling, a horizontal baffle will retain this sediment and cause it to build up; however, the vertical edges permit sediment to be flushed out by the flowing fluids. For clean liquids either a vertical or horizontal edge may be used.

In most oil refineries segmental baffles are used. The path of flow through segmental baffling is not uniform as with disk-and-doughnut baffling. The cross-flow area varies with the width of the shell since the segment area is not symmetrical, as are the areas through the doughnut hole and around the disk. This creates dead pockets of fluid in the path of flow through segmental baffling.

The dam baffle, Fig. 10-I, is used to retain a pool of liquid in the bottom of an exchanger. After a vapor has condensed it may be subcooled. Usually, condensate is cooled at a natural convection rate of heat transfer which, although low, is the best obtainable if there is no positive pressure on the system. Otherwise, if the system is under pressure and a loss of 3-5 psi is permissible, the condensate can be routed through a segmentally-baffled subcooling zone, where a much higher heat-transfer rate will be obtained due to forced convection.

Flow Variables: Inside the Tubes

In selecting heat exchanger tubes, the longest tube with the smallest practical diameter should be employed. These dimensions are dictated by necessity for cleaning, economy, and usual practices in the industry.

When fluid enters the tube at one end and leaves at the other, there is but a single pass on the tube side. Single-pass tubes give the lowest possible velocity inside the tubes. To increase tube velocity, partitions are built into the stationary and floating heads to direct the flow back and forth through the tuble bundle, so that flow is inside only part of the tubes at one time. Thus two to sixteen-pass tubes may be used.

With floating-head construction the use of single-pass tubes requires that a packed-slip-tube joint be used (on the floating head), as shown in Fig. 21. This type construction has the same defect mentioned for the packed, floating-head construction (Fig. 15)—namely, possible leakage through the packing. If steam is in the shell this is not objectionable, but leakage of hydrocarbon oil or vapors is undesirable. Only for special conditions of high temperature and pressure is a single-pass-tube construction used, with an expansion joint in the floating head as shown in Fig. 11-11.

In general, single or odd-numbered tube passes are not used; the number of tube passes is two or a multiple thereof. Mechanical factors determine the number selected, and the number of tube passes should not be increased unless a definite improvement in the heat-transfer rate is obtained. Increased tube passes require that tubes be dropped out to make room for partition plates, and the pattern of heads, gaskets and joints becomes more complicated.

Sometimes it is desirable to have an unequal number of tubes per pass. This presents no mechanical difficulty. For example, when steam at low pressure flows inside

the tubes as the heating medium it may be desired to keep its pressure drop to a minimum. This can be accomplished by placing most of the tubes in the top inlet tube pass where the vapor volume is large. To handle the condensate, whose volume is much less, relatively few tubes are required in the exit bottom tube pass.

The same procedure is followed with vaporizing liquids; just a few tubes are located in the bottom inlet pass to take care of sensible heating and, as vapor is formed, more tubes per pass are provided. If it is desired to super-heat the vapor, more than two tube passes may be used. Using an unequal number of tubes per pass in a two-pass bundle is advantageous where it is necessary to improve the MTD (mean temperature difference). Outlet temperatures of two fluids can be crossed in a single-pass shell having an unequal number of tubes in each of the two tube passes. This cannot be accomplished when there is an equal number of tubes in each pass.

Flow Variables: Inside the Shell

The path of flow around the baffles in a single-pass shell can be seen in Figs. 12 through 20. In a two-pass shell, as seen in Fig. 10-D, the shell is divided into two halves by means of a longitudinal shell baffle. The shell fluid reverses direction halfway in its travels.

Fig. 10-E shows the split-flow condenser, a type of shell which is used for condensing vapors. Vapor enters the shell and the flow is split in half by the solid support plate which divides the shell into two equal compartments. After the vapor flows past the support plates in the upper part of the shell, it crosses over into the second shell pass (after reversing direction) and finally emerges from the shell outlet nozzle. Actually, the velocities and length of travel inside the shell are exactly the same as those in single-pass shells. The improvement here is that the condensate is maintained in contact with the tubes for a longer time—a condition favorable to subcooling. To further promote subcooling the far ends of the longitudinal baffle may be perforated for a length of several feet at each end, through which vapor (condensed in the upper pass) will drip as rain on the tubes in the lower pass. Another advantage is that a better MTD is obtained with split flow than with a single-pass shell.

To reduce the shell pressure drop, the double-split-flow construction (Fig. 10-F) is used. The vapor line is divided into two equal branches, each of which bolts to a shell inlet nozzle. The shell is divided into two separate compartments by a solid, circular support plate. Vapor flowing to each half of the shell is split in half again by the solid support plates. The longitudinal baffles spread the flow along the tube length. Condensate leaves the unit through shell outlet nozzles which join together into a single line. In such a TEMA unit, having 16-ft. tube length, the weight of the tubes is fully supported every 4 ft. Since this is better than the minimum requirement, additional supports are unnecessary.

An alternative method of reducing shell pressure drop in a condenser is by use of the divided-flow arrangement (Fig. 10-G). This consists of two shells, one stacked above the other and bolted together at the shell nozzles. Vapor enters the shell inlet and is divided in half by a solid support plate. Flowing past the support plates the mixture of liquid and vapor passes from the top shell outlet nozzles into the bottom shell inlet nozzles. There it flows past another support plate, with the condensate leaving the condenser through bottom shell, single outlet.

Comparing double-split flow with divided flow, it is seen that the former is accomplished in one shell while the latter requires two. However, since many condenser installations are so large that two, four or six shells are required the two shells are already available. Divided flow is better in requiring only one inlet and one outlet connection and in having simpler internal baffling.

When vapor is generated from the boiling liquid it may be desirable to keep the amount of liquid entrained by rising vapor to a low value, or eliminated. For liquid vaporizing in the shell of an exchanger this can be accomplished by keeping an open volume above the liquid level, through which the vapor produced can travel at a velocity sufficiently low that droplets of entrained liquid will have an opportunity to settle from it. An example of this is the kettle-type reboiler illustrated in Figs. 22 and 23.

Fig. 22 has a U-tube, floating head and bonnet which is suitable when steam is used as the heating medium. The unit shown in Fig. 23 has straight tubes, which require a larger shell opening and shell diameter than the U-tube type. It will be noted that the shell outlet connection for both of these is located midway along the tube length. The generated vapor has to travel through that cross-sectional area perpendicular to tube length and located above the liquid level, in order to leave the shell. Thus it is evident that if the vapor outlet were placed at the end of the shell the cross-sectional area would have to accommodate all the vapor produced. By placing it at the center only half the dome area is needed for the same vapor velocity. This midway position corresponds to the minimum dome area.

Fig. 25—Open area above the tube bundle allows easy distribution for vapor coming into a condenser.

Fig. 26—A large area around the tube bundle will aid in vapor distribution.

A chiller in which a fluid inside the tubes is cooled by the evaporation of a refrigerant in the shell is shown in Fig. 24. Fixed-tubesheet construction, made entirely of steel, is adequate because of the small temperature difference between the two fluids.

Flow variables inside the shell, for a steam generator, are shown in Fig. 10-I. It is quite like the reboiler of Fig. 23 except that additional precaution is taken to remove entrained droplets of water from the steam by means of a dry pipe. This dry pipe is a horizontal length of pipe closed at both ends and perforated along its length. Water is knocked out as the steam passes through the small holes.

Getting vapor out of the shell has been described; how to get the vapor into the shell must also be considered. At low pressures the volume of a vapor is large, and the allowable loss small. These conditions sometimes pose a problem in condenser design. An area equal to the inlet line size is required above the tube bundle to distribute the vapor to it. This area may be either above the tube bundle (Fig. 25), around the tube bundle (Fig. 26), or in a vapor belt around the shell (Fig. 10-I). The vapor

belt is an enlarged area through which vapor surrounds the shell for a width of say 6 in, and the shell has openings cut out to admit the vapor to the tube bundle in every quadrant.

Finned Tube

The use of extended-surface pipe and tubing is admirably suited to certain duties. It may be used to advantage when the coefficient of heat transfer of one fluid is small and of the other fluid is large. Examples of its use are found in heating fuel oil by means of steam, gas cooling and heating, and condensing refrigerant vapors.

Finned Double Pipe

The earliest application of extended surface to a double-pipe exchanger, developed some 23 years ago, is shown in Fig. 27. The unit consists of an inner 1½-in. I.P.S. schedule 40, steel pipe with 24 fins—each ½-in. high and 0.024 in. wide, as shown in cross section in Fig. 28. This inner pipe is enclosed in a 3-in. I.P.S., schedule 40, outer steel pipe. The finned length of each leg is 20 ft., and the total external surface in the exchanger amounts to 100 sq. ft., *five times* that of the bare pipe. The U-tube, floating head is free to move in response to temperature changes and the finned pipe is removable from the shell for cleaning. These sections are good for a maximum working pressure of 500 psi.

In one type unit fins are attached to the pipe by simultaneously cutting 24 grooves in the pipe, laying the fin strips in the grooves, and forcing the pipe wall up against the strips to form a firm bond of contact. The pipe and fins may be made of any metal or combination of metals. Sections are also fabricated by a method in which fins are attached to the pipes by welding. The fins are in pairs, which are connected at the base in the shape of an elongated U. These sections have the advantage of low cost. In instances where only a small amount of surface is required the shell-and-tube exchanger cannot compete with these. Because of their small diameter they are capable of withstanding high pressure.

If a number of finned sections are used in an installation, only a few are required for spare; with a shell-and-tube exchanger a duplicate exchanger is required as a spare. Finned sections are flexible in use for, by properly combining sections, they can be used for different duties; usually the shell-and-tube exchanger is good only to handle the duty for which it was designed.

Fin Cooler

Extended surface has long been used for heating or cooling air. The air flows perpendicularly across the tubes, which have been set at each end into headers. The coefficient of heat transfer for atmospheric air blown across a bank of bare tubes is approximately 10. If fins are placed on a bare tube the overall coefficient of heat transfer is not decreased much, therefore the fins are particularly useful. A 1-in. O.D. tube, with 2-in. O.D. circular fins wound helically at a spacing of 9 fins per inch (Fig. 29), has 12.68 times the surface of the bare tube. Such units are used where the supply of cooling water is either totally lacking, scarce, or fouled so badly that its use creates a maintenance problem requiring frequent cleaning of heat exchangers.

The use of atmospheric air as a coolant establishes the overall heat-transfer coefficient at the very low level of approximately 10, whereas, if the same duty were performed in a water-cooled unit an overall rate as high as 100 might be obtained. Generally, the use of transverse-fin tubing is resorted to when the use of cooling water is impractical. An air-cooled, finned exchanger installation is shown in Fig. 30.

Low Fin Tubing

During the past ten years a new form of fin tubing has been on the market. It is fabricated by extruding the tube-wall metal in a continuous helical fin such that fin and tube are integral. In a typical size, shown in Fig. 31, the fins are approximately 1/20-in. high, 1/80-in. wide, and have an outside diamter of ¾-in.; there are 19 fins per inch. This tube has 2½ times the external surface of a ¾-in. O.D. bare tube. Because of its small outside diameter such a tube can be used in a heat exchanger on the same close pitch used for bare tubes. It is claimed by the manufacturer that fouling deposits on low-fin tubing are no worse than on bare tubing. This type of tubing may be used to advantage in condensers and water-cooled units.

Courtesy of Griscom-Russell Co.

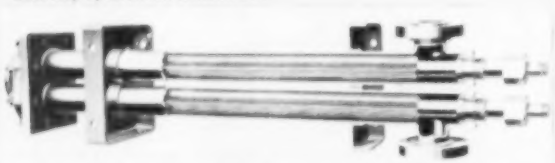


Fig. 27—Extended fins on this double-pipe exchanger provide greater heat transfer surface in a small space

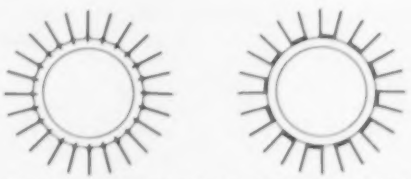


Fig. 28—One method of attaching extended fins is to insert them in grooves, which have been plowed into the tube surface. Another method is by welding special strips to the tube

Courtesy of Griscom-Russell Co.

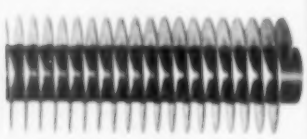


Fig. 29—Helically-wound circular fins greatly increase the heat-transfer surface

Fig. 30—Air-cooled exchangers with fin tubes are used where water is scarce

Fig. 31—Another method of producing finned tubing is to extrude the tube-wall with an integral fin

Courtesy of Wolverine Tube Div., Calumet & Hecla, Inc.

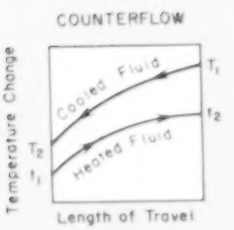


Fig. 32—Temperature profile of two fluids in counterflow show temperature change in both fluids

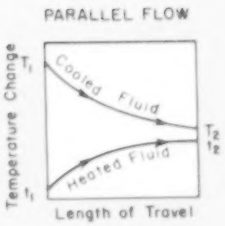


Fig. 33—In parallel flow the temperature of the heated fluid can never equal that of the cooling fluid

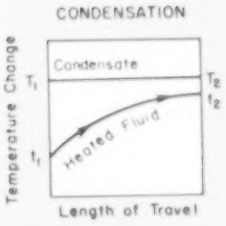


Fig. 34—During condensation of a vapor its temperature remains constant

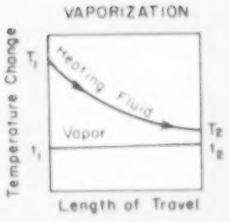


Fig. 35—During vaporization the temperature of the boiling saturated liquid remains constant

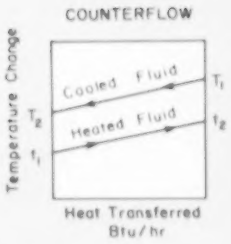


Fig. 36—Plotting transferred heat against temperature change shows a straight-line relationship.

Process Design

Basic Equation of Heat Transfer

WHEN heat is transferred by conduction or convection it follows the basic law expressed by the equation:

$$q = UA\,\Delta t \qquad (1)$$

For metal tubes, A is the surface of the outside wall.

The operating process conditions determine the quantities of fluids which must be heated or cooled through a certain temperature range. Or, if two liquids are interchanging heat, then the flow quantities of each and their initial and final temperatures are known. From this starting information, q, the amount of heat transferred, can readily be calculated. For sensible heat transfer, q is simply the flow quantity in lbs/hr. x the difference in initial temperature and final temperature x its specific heat. If the fluids undergo a change in state (either vaporization or condensation), the latent heat involved in making this change is included as part of the total.

Mean Temperature Difference (MTD)

Fig. 32 shows the temperature profile of two fluids in counter flow. The temperatures of the two fluids are plotted against their length of travel in a unit similar to a double pipe where true counter flow exists. Such a drawing represents actual temperature conditions of the two fluids along the length of pipe.

Fig. 33 is a similar representation of two fluids in parallel flow. The greatest temperature difference exists as the fluids enter the unit; as they flow alongside each other in the same direction, the temperature difference decreases at a progressively slower rate. In parallel flow, the temperature of the cold fluid can never rise as high as the lowest temperature of the hot fluid — as can occur with counter flow.

Figs. 34 and 35 are similar representations with one medium at constant temperature, such as a condenser or evaporator with the other fluid being heated or cooled as it flows along the heat-transfer surface. The curvature of the line indicates the temperatures at different points along the surface.

Fig. 36 shows the counter flow condition again, plotted to different coordinates. This time, temperatures are plotted against quantity of heat transferred, rather than tube length. In this case, the representation is a straight line, and the rate of temperature change between the hot and cold media is a straight-line function. By subtracting the two temperature levels (the cold medium from the hot medium) we obtain a straight-line difference of these two temperature levels.

By integrating the two, the change in temperature with change in heat transferred, we derive the equation for logarithmic temperature differences which prevails in either counter flow or parallel flow. This equation is:

$$t_m = \frac{\Delta t_1 - \Delta t_2}{\ln \dfrac{\Delta t_1}{\Delta t_2}} \qquad (2)$$

Δt_1 is the temperature difference of the fluids at one end of the exchanger (the larger value), Δt_2 equals the temperature difference of the fluids at the other end of the exchanger (smaller value), and Δt_m is the logarithmic mean temperature difference. Fig. 37 is a chart for obtaining logarithmic mean temperature difference.

In most heat exchangers, we do not have true counter flow due to restrictions of mechanical construction. The usual case is a single-pass shell and two (or more) pass tubes. The shell fluid comes in at one end and is directed by means of baffles to pass back and forth across the tube bundle — after which it emerges at the other end of the shell. The tube-side medium, however, flows back and forth along the tubes at least twice. In this arrangement, we have counter flow between the hot and cold media in one tube pass, and parallel flow in the other tube pass. Both must be accounted for. Values for this type of flow have been worked out, and correction factors by which the logarithmic MTD are multiplied to obtain the effective MTD are shown in Fig. 38, for single-pass, two-pass, three-pass, and four-pass shells.

In order to use these charts, the parameters R and P

DIRECTIONS FOR USE OF MTD CHART

This chart gives the counter-current mean temperature difference from the formula

$$MTD = \frac{GTTD - LTTD}{\text{Log.}\frac{GTTD}{LTTD}}$$

For example:

$T_1 \longrightarrow T_2$	180 ⟶ 134
$t_2 \longleftarrow t_1$	100 ⟵ 80
	80 54
	66

From MTD Chart above,
Counter-current MTD = 66

Courtesy of Griscom-Russell Co.

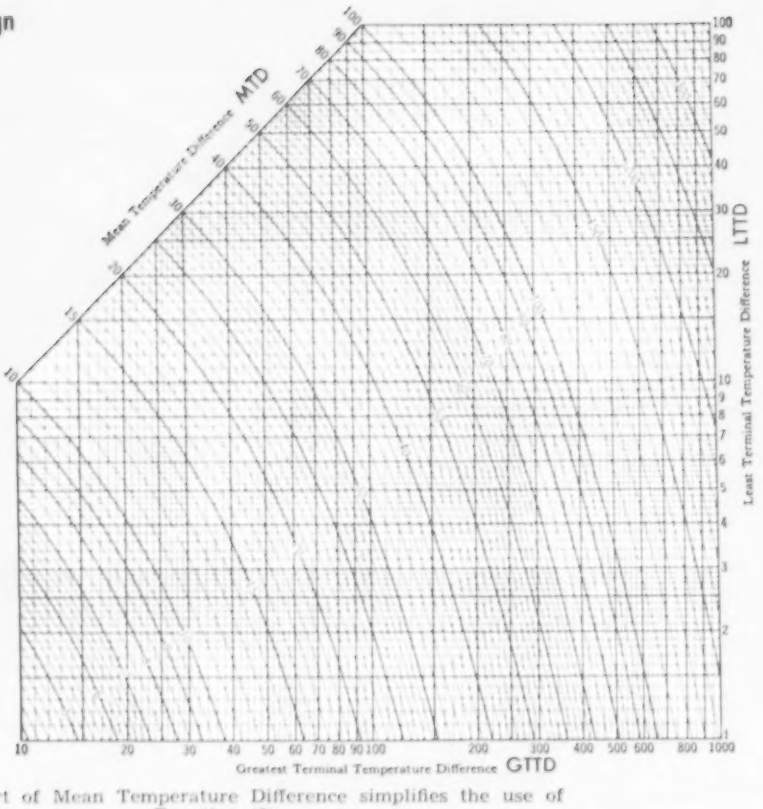

Mean Temperature Difference MTD
Least Terminal Temperature Difference LTTD
Greatest Terminal Temperature Difference GTTD

Fig. 37—This chart of Mean Temperature Difference simplifies the use of Equation (2)

are worked out in terms of the terminal temperatures of the hot and cold media. In using the correction factor F for a single-pass shell with multi-pass tubes, an important fact to remember is that the temperature correction factor is 0.8 when outlet temperatures of the hot and of the cold fluids are the same. When attempting to cool down the hot fluid below the outlet temperatures of cooling water, then the temperature correction factor plummets, and it is impractical to cool beyond this temperature in a single-pass shell. The charts given in Fig. 38 should not be used when the value of F is less than 0.8; if the value is less than 0.8 (as obtained for a single-pass shell) then two shell passes should be used.

Overall Coefficient of Heat Transfer

Heat is transferred from a hot to a cold fluid. The fluids are separated by a metal boundary wall through five resistances: (1) the resistance to heat transfer of the hot fluid, (2) the resistance to heat transfer of the cold fluid, (3) the resistance of the metal wall, and (4) and (5) the resistance of the fouling on each side of that wall. These five resistances are evaluated then added together, and the reciprocal of this sum is the over-all coefficient of heat transfer.

In order to calculate the heat-transfer coefficients of fluids flowing inside and outside the tubes, it is necessary to consider at the same time the pressure loss of the fluid in its flow through the heat exchanger, for this pressure drop is important. In fact, it is sometimes of paramount importance because the allowable pressure drop may be so small that the design of the heat exchanger is radically affected because of this limitation. Therefore, let's consider the conditions for heat transfer and pressure drop both inside and outside tubes.

Our first subject of consideration is fluids flowing inside tubes.

Fluid Inside Tube

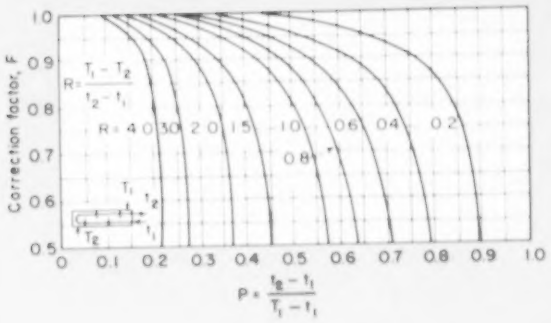
Coefficient of Heat Transfer

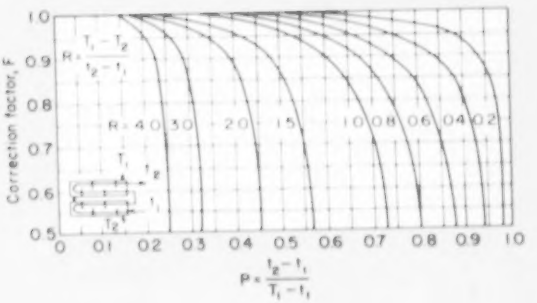
The pertinent factors involved in the heat-transfer coefficient for fluid flow are generally plotted against Reynolds numbers. The Reynolds number for flow inside tubes is the term $D_i G_t / \mu$, a dimensionless term. This effect of turbulent flow inside tubes was first noted by Osborne Reynolds in 1883, and it is after him that this criterion of flow is named.

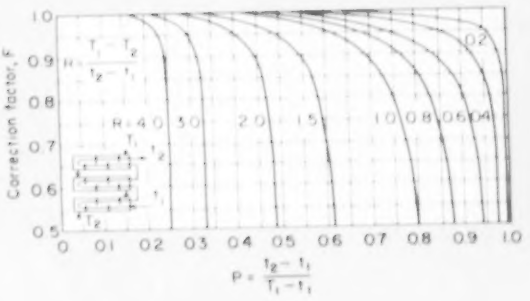
Referring to the chart for coefficient of heat transfer for fluids inside tubes, Fig. 39, we see that up to Reynolds numbers of 2,100 we have a series of parallel straight lines. These lines rise rapidly from that point on and begin to converge. By the time they have reached a Reynolds number of 10,000, the different lines for various L/D_i ratios merge into one, so that the L/D_i ratio is no longer a factor at high Reynolds numbers. The slope of the lines at Reynolds numbers below 2,100 shows that the heat-transfer coefficient in this region—which is the region of streamline or viscous flow—is proportional to the cube root of the velocity inside the tube. In the turbulent region of flow, beginning at a Reynolds number of 10,000, the heat-transfer coefficient is proportional to the mass velocity to the 0.8 power. The equation of the parallel lines in the streamline flow region is: (*Cont. on p.* 116)

Terms Used in Process Design

A = surface separating hot and cold media, sq.ft.
c = specific heat, Btu/(lb.)(°F.)
C_{sf} = constant depending on the surface and fluid
D = outside diameter of tube, ft.
D_e = equivalent diameter of flow area, ft.
D_i = inside diameter of tube, ft.
D_v = diffusion coefficient, sq.ft./hr.
f = friction factor
g = acceleration of gravity, 4.17×10^8 ft./(hr.)(hr.)
G = mass velocity of flow, lb./(hr.)(sq.ft.)
G_b = mass velocity through baffle opening lb./(hr.)(sq.ft.)
G_c = maximum crossflow mass velocity, lb./(hr.)(sq.ft.)
G_e = weighted mass velocity $(= \sqrt{G_c \times G_b})$, lb./(hr.)(sq.ft.)
G_t = mass velocity inside the tube, lb./(hr.)(sq.ft.)
h = coefficient of heat transfer, Btu/(hr.)(sq.ft.)(°F.)
h_m = mean value of heat-transfer coefficient for entire tube bundle, Btu/(hr.)(sq.ft.)(°F.)
k = thermal conductivity, Btu/(hr.)(sq.ft.)(°F.)/ft.
K = coefficient of mass transfer, lb.moles/(hr.)(sq.ft.) atmospheres
L = tube length, ft.
M_m = molecular weight of mixture(vapor + inert gas)
M_v = molecular weight of vapor
N_{Re} = Reynolds number
Δp = pressure drop, lb./sq.ft.
$\Delta p'$ = pressure drop, lb./sq.in.
p_c = partial pressure of vapors at t_c, atm.
p_i = partial pressure of vapors at t_i, atm.
p_{BM} = logarithmic mean of the vapor pressures at the interface and at the vapor stream, atm.
P = Total pressure on system, atm.
q = quantity of heat, Btu/hr.
r = resistance, the reciprocal of h
r_h = hydraulic radius of flow area, ft.
$sp.g.$ = specific gravity referred to water at 60°F.
t = thickness of wall tube, ft.
t_c = condensate temperature, °F.
t_f = average film temperature, °F.
t_i = vapor temperature, °F.
t_w = water temperature, °F.
Δt = temperature difference, °F.
Δt_b = temperature difference between heating surface and boiling liquid, °F.
Δt_m = logarithmic mean temperature difference, °F.
U = overall heat-transfer coefficient, Btu/(hr.)(sq.ft.)(°F.)
U_c = condensing coefficient for pure vapor — between t_i and t_w, Btu/(hr.)(sq.ft.)(°F.)
w = rate of flow, lb./hr.
w_c = rate of flow of condensate from lowest point on condensing surface, lb./hr.
β = thermal coefficient of cubical expansion, 1/°F.
λ = latent heat, Btu/lb.
μ = viscosity at average temperature, lb./(hr.)(ft.)
μ_f = viscosity at average film temperature, lb./(hr.)(ft.) ture, lb./(hr.)(ft.)
μ_w = viscosity at tube-wall temperature, lb./(hr.)(ft.)
ρ = density at average fluid temperature, lb./cu.ft.
ρ_f = density at film temperature, lb./cu.ft.
ρ_l = density of liquid, lb./cu.ft.
ρ_v = density of vapor, lb./cu.ft.
σ = surface tension, lb./ft.







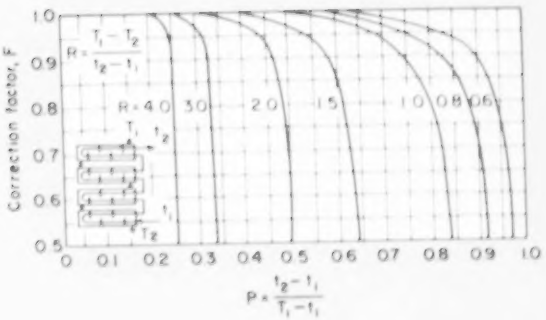


Fig. 38—Correction factors for various combinations of shell passes and tube passes are used with Fig. 37

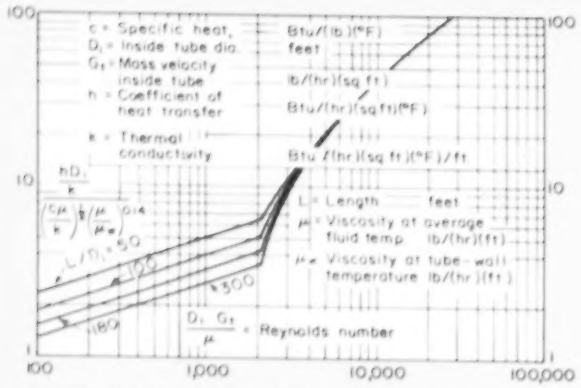

c = Specific heat, Btu/(lb)(°F)
D_i = Inside tube dia. feet
G_t = Mass velocity inside tube lb/(hr)(sq ft)
h = Coefficient of heat transfer Btu/(hr)(sq ft)(°F)
k = Thermal conductivity Btu/(hr)(sq ft)(°F)/ft
L = Length feet
μ = Viscosity at average fluid temp lb/(hr)(ft)
μ_w = Viscosity at tube-wall temperature lb/(hr)(ft)
L/D_i = 50
100
80
D_i G_t / μ = Reynolds number
100
1,000
10,000
100,000

Fig. 39—Relationship of heat-transfer coefficient with Reynolds Number

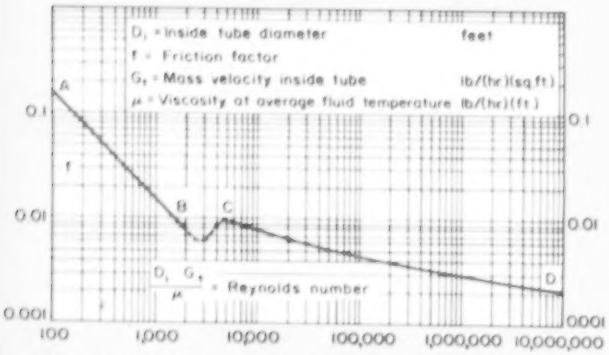


Fig. 40—Relationship of friction factor for fluid flow inside a pipe and the Reynolds Number

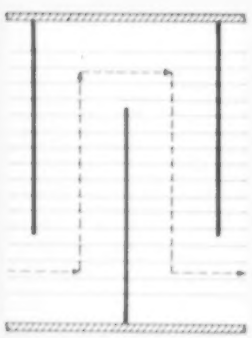


Fig. 41—Idealized flow path in a segmentally baffled shell looks like this

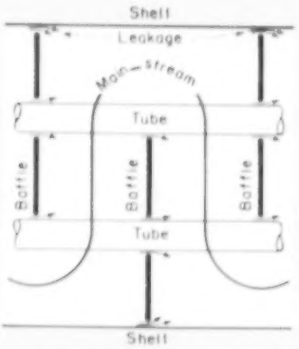


Fig. 42—Leakage occurs between the segment baffles and the tubes

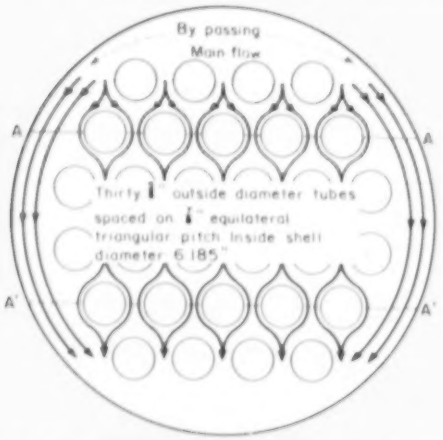


Fig. 43—Bypassing occurs between the tube bundle and shell

$$\frac{hD_i}{k} = 1.86\left[\left(\frac{D_iG_t}{\mu}\right)\left(\frac{c\mu}{k}\right)\left(\frac{D_i}{L}\right)\right]^{0.33}\left(\frac{\mu}{\mu_w}\right)^{0.14} \quad \ldots\ldots(3)$$

When the flow is extremely viscous a correction for natural convection must be taken into effect. The correction factor is

$$0.8\,(1 + 0.015\,N_{Gr}^{0.3}) \quad \ldots\ldots(4)$$

The heat transfer coefficient is multiplied by this term, in which the Grashof number (N_{Gr}) is

$$N_{Gr} = \frac{(\beta\,\Delta t)\,(D_i^3\,\rho g)}{\mu^2} \quad \ldots\ldots(5)$$

Since the variation of the experimental points from the lines shown on this chart is about ± 40-50% it is felt that considerable more experimental work is required to attain a closer correlation.

In the region for turbulent flow the equation for heat transfer is

$$\frac{hD_i}{k} = 0.027\left(\frac{D_iG_t}{\mu}\right)^{0.8}\left(\frac{c\mu}{k}\right)^{0.33}\left(\frac{\mu}{\mu_w}\right)^{0.14} \quad \ldots\ldots(6)$$

This equation holds for liquids and gases over the entire range of pressures. It represents experimental data within a precision of ± 20%.

Between the two regions described, lies the intermediate region of changeover from streamline to turbulent flow. To obtain the heat-transfer coefficient in this region, it is necessary to use the chart of Fig. 39. The Reynolds number is evaluated and the point on the curved line corresponding to it is located. This value is equated to the ordinate of Fig. 39 and from it, h, the heat-transfer coefficient, is calculated.

Pressure Drop

The frictional pressure drop developed by fluids flowing through tubes or pipes is expressed by the equation

$$\Delta p' = \frac{5.338}{10^{13}} \times \frac{fG_t^2}{D(\text{sp.g.})} \quad \ldots\ldots(7)$$

The friction factor, f, in this equation is a function of the Reynolds number. In Fig. 40, line AB represents the viscous region. The equation of this line, which has a theoretical basis and derives from Poiseuille's law is

$$f = \frac{16}{\frac{D_iG_t}{\mu}} \quad \ldots\ldots(8)$$

The line for flow of Reynolds number above 2,100 may be expressed approximately by the equation

$$f = \frac{0.048}{\left(\frac{D_iG_t}{\mu}\right)^{0.2}} \quad \ldots\ldots(9)$$

From these equations it is seen that the pressure drop is directly proportional to the velocity through the tubes in streamline flow, whereas in turbulent flow, the pressure drop is proportional to the 1.8 power of the velocity inside the tubes.

Segment-Baffled Shell

Fig. 41 represents an idealized concept of the flow path of fluid through a shell with segmental baffles. The flow traverses the tube bundle, then turns and flows parallel

to the tubes through the baffle cutouts. Its crossflow path across the tube bundle is from the centroid of one baffle cutout to the centroid of the next baffle cutout. In this flow path, there is leakage area between the baffle edge and the inside diameter of the shell and also between the tubes and the tube holes in the baffles. At these points the fluid is diverted from the main flow stream as shown in Fig. 42, and leaks through these clearances. Considerable bypassing occurs also in the annular clearances between the tube bundle and the inside diameter of the shell, as indicated in Fig. 43. The fluids in following the path of least resistance will flow through the open area outside the tube bundle rather than into the closely-packed structure of the tube bundle.

In Figs. 44, 45, and 46 are shown typical tube layouts, each for an 18-in. diameter shell. In Fig. 44, the tubes are laid out on a diamond pitch. This is used only for clean fluids not requiring manual cleaning between the tubes. Fig. 45 is a tube layout for the same size shell in which the tubes are spaced on a square pitch. Fig. 46 is the same square pitch which has been rotated at an angle of 45° from the horizontal. The crossflow areas for each of these tube bundles and number of restrictions to flow are indicated in the Figures.

Referring again to Fig. 41, it is noted that there are two different velocities: one (G_c) at right angles to the tube axis, and another (G_h) through the baffle cutout.

Pressure Drop

The pressure drop through the baffle cutouts is expressed by the following equation:

$$\Delta p'_h = \frac{2.9}{10^{10}} \frac{G_h^2}{(\text{sp.g.})} \qquad (10)$$

The other component of pressure drop across the tube bank may be obtained from Fig. 47, in which is plotted the friction factor vs. Reynolds number. For tube layouts, in which the tube pitch is 1¼ x the outside diameter of the tube, the friction factor in the viscous flow region is expressed by the relation

$$f = \frac{60}{\frac{DG_c}{\mu}} \qquad (11)$$

The equation of the line for friction factor in turbulent flow is

$$f = \frac{0.99}{\left(\frac{DG_c}{\mu}\right)^{0.2}} \qquad (12)$$

The shell-side pressure drop is computed by use of these two equations and the shell baffling is adjusted to utilize the allowable pressure drop for maximum heat-transfer coefficient. From these relations, it is seen that the pressure drop in viscous flow is directly proportional to the velocity across the tube bundle. In turbulent flow, the pressure drop is proportional to the velocity across the tube bundle, raised to the 1.8 power.

Coefficient of Heat Transfer

The coefficient of heat transfer inside baffle shells is expressed by the relation

$$\frac{hD}{k} = 0.22\left(\frac{DG_c}{\mu}\right)^{0.6}\left(\frac{c\mu}{k}\right)^{1/3}\left(\frac{\mu}{\mu_w}\right)^{0.14} \qquad (13)$$

The segmental baffling may be varied within certain limits to change the velocities either across the tube bank or through the baffle opening.

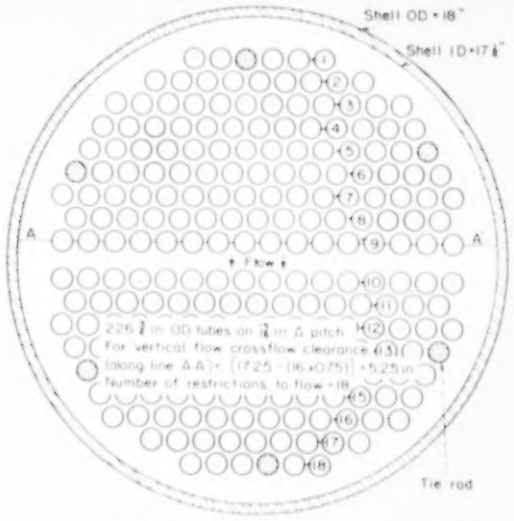

Shell OD = 18"
Shell ID = 17¼"
A
A
Flow
226 ¾ in. OD tubes on ¾ in. Δ pitch
For vertical flow, crossflow clearance (G)
(along line A-A) = [17.25 − (16 x 0.75)] = 5.25 in.
Number of restrictions to flow = 18
Tie rod

Fig. 44—Typical tube layout based on a diamond pitch

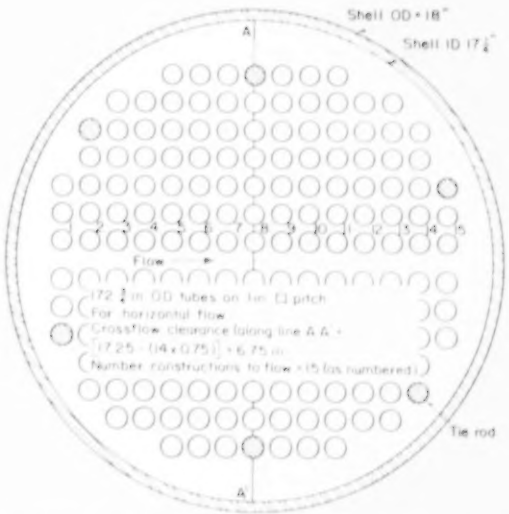

Shell OD = 18"
Shell ID 17¼"
A
Flow
172 ¾ in. OD tubes on 1in. □ pitch
For horizontal flow
Crossflow clearance (along line A-A =
[17.25 − (4 x 0.75)] = 6.75 in.
Number constrictions to flow = (5 (as numbered))
Tie rod
A

Fig. 45—Typical layout of tubes on a square spacing

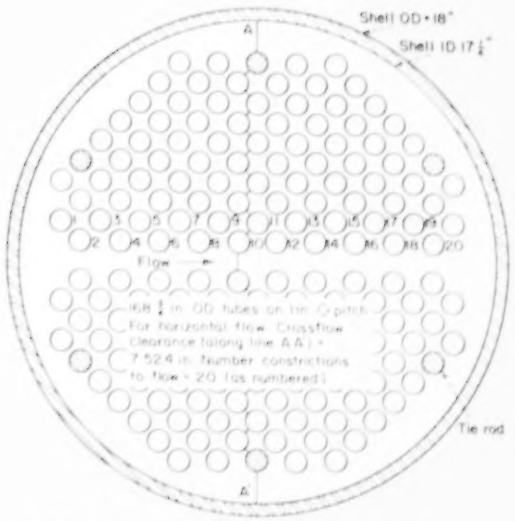


Fig. 46—Typical tube layout on a diagonal-square pattern

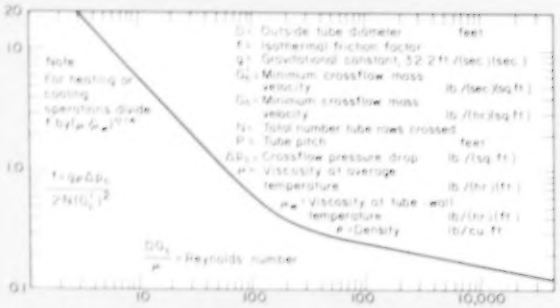

20
10
1.0
0.1
10
100
1000
10,000
Note
For heating or cooling operations divide
D_o = Outside tube diameter, feet
f = Isothermal friction factor
g' = Gravitational constant, 32.2 ft./(sec.)(sec.)
G_c = Minimum crossflow mass velocity, lb./(sec.)(sq.ft.)
G_h = Minimum crossflow mass velocity, lb./(hr.)(sq.ft.)
N_r = Total number tube rows crossed
P = Tube pitch, feet
ΔP_c = Crossflow pressure drop, lb./(sq.ft.)
μ = Viscosity at average temperature, lb./(hr.)(ft.)
μ_w = Viscosity at tube wall temperature, lb./(hr.)(ft.)
ρ = Density, lb./cu.ft.
$\frac{DG_c}{\mu}$ = Reynolds number

Fig. 47—This chart relates the velocity at right angles to the tube axis (G_c) with the Reynolds Number

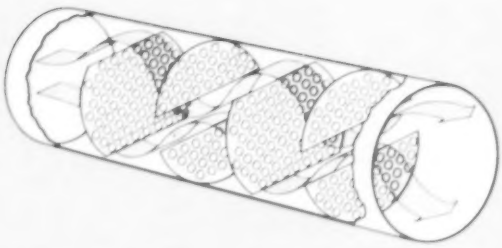


Fig. 48—Baffling arranged like this cuts the crossflow pressure drop in half

Considering first the baffle cutout, the largest cut which can be removed from a baffle is 45% of the area, and the smallest cutout considered suitable is 20%. Thus, there is a possible variation in cutout area of 2¼ times. Now, if only the baffle cutout is varied and the opening decreased from 45% to 20%, the velocity increases 2¼ times. The effect of this increased velocity on overall heat-transfer coefficient is to increase it 28%. The effect on pressure drop through the baffle cutout alone is to increase it to five times its former value.

There is more chance for variation in crossflow area by varying the baffle spacing than there is with size of cutout. It is possible to change the baffle spacing five times or more. Considering the case where twice as many baffles are used in order to double the crossflow velocity, the over-all increase in heat-transfer coefficient caused by this change will amount to 23%. The crossflow pressure drop will increase to 3½ times its original value as a consequence of doubling the crossflow mass velocity. In a case where just half as many baffles are used, crossflow velocity is reduced to half its former value with the consequence that the heat-transfer coefficient drops to 81% of its original value and the crossflow pressure drops to 29% of its original value. Usually in shell-side pressure-drop calculations, the crossflow component is the major component in the total pressure drop.

The baffling in Fig. 41 might be rearranged to the form shown in Fig. 48, in which the values of G_c and G_h are kept the same as before. However, the distance of crossflow path is only half as long as it was before. For this reason, the crossflow pressure drop in Fig. 48 is only one-half that of Fig. 41. Thus, by this simple change in baffle arrangement, the same heat-transfer coefficient is retained and the over-all pressure drop is cut almost in half.

Condensation

Reynolds Number

When vapor condenses on a tube and the condensate runs along the tube, evaluation of the Reynolds number will determine whether the condensate is in streamline or turbulent motion. The Reynolds number for flow of condensate is evaluated in the following manner:

Liquid outside Vertical Tube

Fig. 49 shows a vertical tube on which the amount of condensate increases from the top to the bottom of the tube. Fig. 50 shows a cross-sectional area perpendicular to the tube axis and any distance along the tube length. On any cross-sectional area, the liquid film shown in Fig. 50 may be taken as equal to the thickness of the film × the perimeter of the outside of the tube. Cross-sectional area of film = $t \times D$. Reynolds number equations are:

$$N_{Re} = \frac{D_e G}{\mu} = \frac{4r_h G}{\mu} \quad \ldots\ldots (16)$$

$$= \frac{4w}{\pi D \mu_f} \quad \ldots\ldots (16a)$$

Liquid outside Horizontal Tube

A tube in a horizontal position with vapor flow perpendicular to the tube axis is shown in Fig. 51 and Fig. 52. Although the thickness of the condensate film has been found experimentally to be a minimum at the top of the tube and maximum at the bottom, it is assumed that the film thickness is everywhere equal. The cross-sectional area of the film = $2tL$. Reynolds number for this case is: case is:

$$N_{Re} = \frac{D_e G}{\mu} = \frac{4r_h G}{\mu} \quad \ldots\ldots (17)$$

$$= \frac{2w}{\mu_f L} \quad \ldots\ldots (17a)$$

The Nusselt Relations

In 1916, Nusselt derived mathematical relationships for the condensation of vapors. Based upon theoretical considerations, Table 1 lists equations for vertical tube bundles and horizontal tube bundles.

In a vertical tube bundle, the condensate film is thinnest

TABLE 1—These are the theoretical relationships for vapor condensation

(Based on Nusselt relations, streamline flow)

Kind of Surface	Mean Heat Transfer Coefficient, h_m
Vertical Tube Bundle	$0.925 \left(\frac{k^3 \rho^2 g}{D \mu w}\right)^{1/3}$
Horizontal Tube Bundle	$0.955 \left(\frac{k^3 \rho^2 g}{L \mu w}\right)^{1/3}$

Fig. 49 — Condensation may be dropwise under controlled conditions

Fig. 50—In cross section the thickness of the film on a vertical tube is assumed constant

Fig. 51—On a horizontal tube the condensation film is a minimum thickness at the top

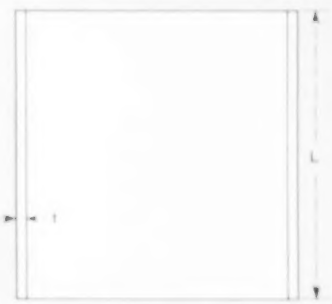


Fig. 52—For calculations, film thickness on a horizontal tube is assumed to equal "t"

at the top of the tube and thickest at the bottom. As a result, the heat-transfer coefficient is a maximum at the top of the tube, decreasing to a minimum at the bottom. Similarly, in a horizontal tube bundle the heat-transfer coefficient of condensation varies from the top to bottom of the tube bundle.

The equations in Table 1 account for this variation in rate by giving the mean-heat-transfer coefficient, expressed in terms of condensate loading(w/L). These equations are based upon all the vapor entering the condenser — not the vapor plus the condensate.

Turbulent Flow: Condensate Film on Vertical Tube

For streamline flow of condensate on a vertical tube, the thickness of the condensate film increases until it reaches a certain value. As has already been seen, the heat-transfer coefficient for condensation is inversely proportional to the film thickness. Thus, the thicker the film, the lower the heat-transfer coefficient of condensation. However, the heat-transfer coefficient was observed to decrease up to a certain point, and then the effect was reversed and the heat-transfer coefficient rose again. The point at which this transformation took place was at a Reynolds number of about 1,600, indicating that turbulance in the liquid film increases the heat-transfer coefficient. A chart plotting the relation of heat-transfer coefficient vs. Reynolds number is shown in Fig. 53.

Condensation of Vapor in Presence of of Non-Condensable Gas

A cross-sectional view of a vapor condensing in the presence of non-condensable gas on a tube wall is shown in Fig. 54. This figure shows the resistance to heat flow in the temperature profile.

From the vapor to the interface, heat is transferred by two mechanisms: (1) the sensible heat of the vapor is removed in cooling it from t_v to t_i at a convection gas cooling rate, and (2) the latent heat of the condensable vapor is removed only after the condensable vapor has diffused through the non-condensable gas to reach the tube wall. Thus, the transfer of the latent heat, which is most of the heat, is governed by the laws of mass transfer. By equating the heat flux ($U\Delta t$) entering and leaving the interface, we have the equation

$$h(t_v - t_i) = KM_v\Delta(p_{BM})(p_v - p_i)/(t_v - t_i) \quad (18)$$

The essential difference between this condition and that for condensation of a pure vapor is that for a pure vapor $t_i = t_v$, whereas when non-condensable gas is present, t_i is lower than t_v. To solve, it is necessary merely to evaluate the above equation, selecting a value of t_i by trial and error which will satisfy the equilibrium condition. This procedure is repeated for different points in the condenser. The amount of surface required is calculated by using U_c and MTD based on t_v and t_w over the entire condensing range.

In order to be able to evaluate the equation given for equilibrium at the interface point for condensation of vapor in the presence of an inert gas, it is necessary to deal with the subject of simultaneous heat and mass transfer. The following basic relations state the analogy between friction, heat transfer and mass transfer: for friction:

$$f_f = \frac{1}{2}f \quad (19)$$

heat transfer:

$$j_h = \frac{h}{cG}\left(\frac{c\mu}{k}\right)^{2/3} \quad (20)$$

mass transfer:

$$j_D = \frac{Kp_{BM}}{G}\left(\frac{\mu}{\rho D}\right)^{2/3}M_v \quad (21)$$

flow inside tubes:

$$f = j_f = j_h = j_D = \frac{0.0027}{\left(\frac{DG}{\mu}\right)^{0.2}} \quad (22)$$

flow across tube banks:

$$f = j_f = j_h = j_D = \frac{0.33}{\left(\frac{DG}{\mu}\right)^{0.4}} \quad (23)$$

The following stepwise procedure is recommended for use in solving the equilibrium Equation (18) with vapor condensing in the shell:

1—by use of Raoult's law of partial pressures calculate how much vapor will condense at inlet and outlet temperatures and at about three intermediate temperatures.

2—obtain the following physical properties at the average of inlet and outlet temperatures and pressures: μ_v, ρ_v, D_v, M_{av}, M_v, s_v, c_v, k_v, $(c\mu/k)_v^{2/3}$ and $(\mu/\rho D_v)^{2/3}$.

3—select trial-size unit.

4—calculate G_t, G_w and G_s.

5—calculate Δp_t, Δp_s, Δp_r.

6—calculate h from Equation (13) for flow in segmentally-baffled shells.

7—calculate U_c.

8—calculate j_h which for segmentally-baffled shell is

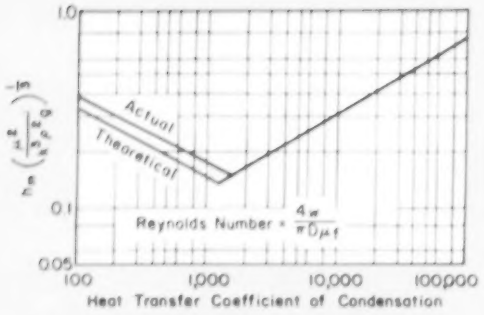


Fig. 53—Relationship of heat-transfer coefficient for condensation and Reynolds Number

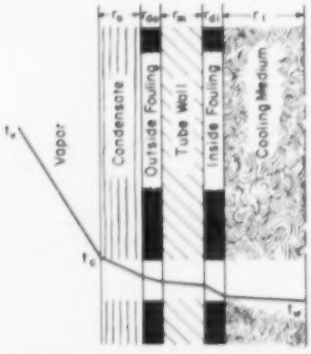


Fig. 54—Temperature profile shows what happens when vapor condenses on a tube wall in presence of non-condensible gas

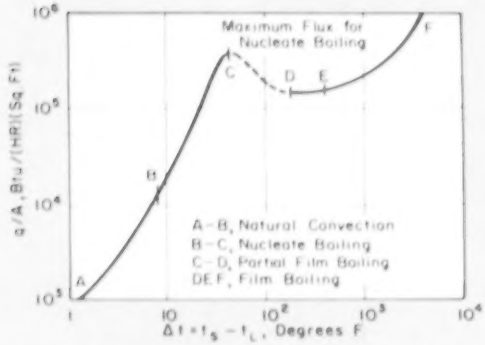

Maximum Flux for Nucleate Boiling
A–B, Natural Convection
B–C, Nucleate Boiling
C–D, Partial Film Boiling
D-E-F, Film Boiling
Δt = t_S − t_L, Degrees F

Fig. 55—Typical curve showing density of heat flux during nucleate boiling of water at one atmosphere

Courtesy of Griscom-Russell Co. and Foster Wheeler Co.

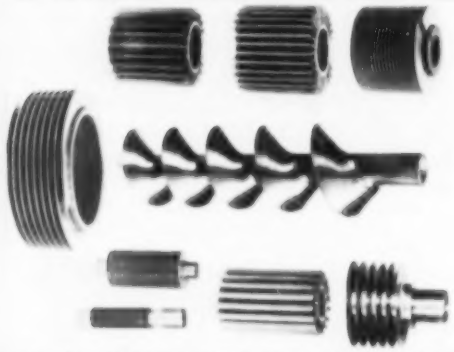


Fig. 56—Extended surfaces on finned tubing can be made in various forms

$$j = \frac{0.22}{\left(\frac{DG_c}{\mu}\right)^{0.4}} \quad \ldots\ldots(24)$$

9—calculate K from the following equation:

$$K = \frac{jG}{M_m p_{BM}\left(\frac{\mu}{\rho D v}\right)^{0.6}} \quad \ldots\ldots(25)$$

$$p_{BM} = \frac{(P - p_i) - (P - p_c)}{\ln \frac{(P - p_i)}{(P - p_c)}} = \frac{(p_i - p_c)}{\ln \frac{(P - p_i)}{(P - p_c)}} \quad \ldots(26)$$

10—corresponding to the inlet t_c, select by trial and error a value of t_i which will balance the equilibrium Equation (18).

11—calculate t_i in a similar manner for each other point.

12—calculate the heat removed between each two successive temperature points including condensate cooling.

13—between each two successive temperature points calculate Δt based on the temperature difference between t_i and t_a.

14—using U_c, calculate the heat-transfer surface required between each two successive temperature points, using δt from step 13 above.

Evaporation

When water is evaporated by a hot surface, the vapor liberated at the heating surface is in the form of bubbles. The size of the bubbles depends on the nature of the heating surface and the surface tension of the liquid.

A rough surface produces nucleate boiling. Liquids with low surface tension, such as organic liquids, will form a bubble quickly, whereas liquids with a high surface tension (water) form a bubble more slowly. The amount of heat transferred is a function of the number of locations on the heating surface from which bubbles originate, and the velocity of these bubbles through the liquid to cause agitation and improve the heat transfer.

When heat is supplied to the water quicker than the vapor bubbles can form and rise through the liquid, then the heating surface becomes vapor-bound and the transfer of heat is slowed down. An example of this is the familiar case of a drop of water dancing on a hot stove. An experimental study was made on the heat transfer of a wire to boiling water under a wide range of temperatures and pressures. The results are shown in Fig. 55.

In this figure, the section AB is the region of natural-convection heating. At a temperature difference of approximately 8°F., the heat-transfer coefficient was approximately 654. Following this from B to C, there is a rise in the chart. This is a section of nucleate boiling for a temperature difference between the water and the hot surface from 8 to 41°F. Corresponding heat-transfer coefficients over this range were 654 to 9,270. From the chart, it is seen that the value of q/A rises rapidly from Δt values of 17 to 41. Section C to D of this chart is a section of partial film boiling and section DEF is the section of film boiling.

As already mentioned, the peak heat-transfer coefficient was 9,270 at a temperature difference of 37.3°F. At a temperature difference of 1,840°F, the heat-transfer co-

efficient was 161; and at a temperature difference of 1,340°F, the heat-transfer coefficient was 143. The latter two values are in the region where the heating element was blanketed with vapor. The effect of pressure on the maximum flux was noted to increase as the pressure on the system was increased. For example, at one atmosphere, the value of q/A was 380,000. At 1,200 psig, the value of q/A was 2,100,000. The peak flux had increased over five times as a result of increased pressure.

Experimental data on the boiling of heptane shows that the heat-transfer coefficient of boiling increases as the pressure on the heptane is increased. The following table shows the effect caused by increased pressure at a constant temperature difference of 30°F:

Pressure psia	Value of h
6.6	650
14.7	850
50	2000
115	4000
215	4800

A general correlation for boiling liquids is given in the following equation:

$$\frac{c\Delta t_e}{\lambda} = C_{sf}\left(\frac{q}{A}\sqrt{\frac{\left(\frac{q}{A}\right)}{g(\rho_l - \rho_v)}}\right)^{n}\left(\frac{c\mu}{k}\right)^{1.0} \quad (27)$$

In the design of evaporators and vaporizers, it is the practice to use heat-transfer coefficients for boiling considerably below the experimental values cited. When water or another pure compound is evaporated, it boils at a constant temperature. On the other hand, when hydrocarbons and petroleum derivatives are vaporized, they do not have a fixed boiling point. It is variable because they are composed of a number of components, with boiling points which vary slightly from each other. Therefore, when petroleum oils are boiled in a reboiler, there is a temperature range associated with the vaporization process, and in addition to the transfer of latent heat, sensible heat also is transferred. In order to take account of the sensible heat, the amount of heat so transferred is calculated at a natural-convection rate. If forced convection occurs in the reboiler, the rate is calculated on that basis. In any event, the heat-transfer rate is considerably below that of boiling, and when the two are compounded to give the over-all rate, it is usually considerably below 300.

When designing evaporators or reboilers, the maximum heat flux must be taken into account. Experimental values of heat flux for benzene and hydrocarbon liquids indicate that the maximum flux is approximately 50,000-60,000. However, in designing reboilers it is customary to limit the maximum flux value to 12,000. In some cases, this means that the unit is made larger because of maximum flux limitation. For example, if the temperature difference is 150°F, and maximum flux of 12,000 is adhered to, then the over-all heat-transfer coefficient, U, is only 80. Usually an over-all heat-transfer coefficient in a steam-heated reboiler will be of the magnitude of 120 instead. However, sufficient surface is put into the unit so that the maximum flux of 12,000 is not exceeded.

Extended Surface

An idea of the various types of finned tubing may be obtained from the photograph in Fig. 56. In this picture we see several examples of helically-wound, transverse, and longitudinal fins. Each type may be attached to the tube wall in several different ways. Not shown is the spine fin which consists of many points projecting from a solid block of metal, like a porcupine.

Besides the shape of the fin, the method of attachment or bond between the fin and tube is of importance. Longitudinal fins are attached to the pipe either by a mechanical bonding or by welding. Transverse fins are attached mechanically or by soldering. It should be pointed out that the fins attached by soldering are not capable of withstanding high temperatures.

The low-finned tubing is made by extrusion from the tube wall and the fin metal is integral with the tube wall. This tubing, of course, is capable of resisting any temperature and pressure that the metal of the tube will. In the case of the integral fin, with soft material such as copper and aluminum, it has been possible to extrude fins $^3/_{32}$-in. high on the tube.

When a metal rod is heated at one end and projects into the surrounding air, it will be found that the projecting end is at a lower temperature than the heated end. The temperature drops along the bar from the heated end to the extended end. The reason is that the rod has resistance to heat transfer. Therefore, the extended fin is not 100% efficient as is the tube wall of a bare tube.

The fin efficiency is defined as the ratio of the temperature difference over the extended surface to that of the temperature difference over the basic surface. Mathematical expressions have been derived for various shapes of fins to express the fin efficiency. They have been derived for longitudinal fins and for transverse fins and charts of fin efficiency are available. The fin efficiency is related to the following factors: fin height, fin width, the thermal conductivity of the metal from which the fin is made, and the heat-transfer coefficient of the fluid outside the fin. The higher the heat-transfer coefficient, the smaller will be the fin efficiency.

As an aid in calculating the over-all heat-transfer coefficient used in a fin tube unit, the following procedure is outlined:

Evaluate:

1 = r_o unfinned
2 = r_{oo} unfinned
3 = r_m
4 = r_{of} (external surface/internal surface)
5 = r_{of} (external surface/internal surface)

The sum $R = 1 + 2 + 3 + 4 + 5$ is obtained by solving the value of r_m by the following:

$$\frac{1 + 2}{\text{fin efficiency}} = 1 + 2 + 3$$

A = calculate 1 above
B = add 1 and 2
C = divide (1 + 2) by the pipe efficiency = 1 + 2 + 3

$$D = r_m = (1 + 2 + 3) - (1 + 2) \quad (28)$$

$$T_m = \left(\frac{T_1 + T_2}{2}\right) - \left(\frac{1 + 2}{1 + 2 + 3 + 4 + 5}\right)\Delta t_m \quad (29)$$

Where T_1 equals the inlet temperature of the medium outside fins, T_2 equals the outlet temperature of the medium outside fins, T_m equals tube wall temperature, and Δt_m equals the over-all MTD in the unit.

Design charts based on experimental points are available for finned double pipe correlating both heat-transfer coefficient and friction factor, and for transverse fins on tubing for a number of spacings covering heat-transfer coefficient and friction factor.

HEAT EXCHANGERS 3

Mechanical Design

Thermal Design Mechanical Factors

BEFORE an exchanger is sized the designer must have decided on the diameter, length and spacing of the tubes. Also the style of baffling to be used inside the shell, as well as its arrangement, must have been determined.

In general, the longest tubes with the smallest practical diameter should be employed because it results in the most compact and least expensive piece of equipment. The diameter of the tube is decided on the basis of the need for cleaning inside the tubes. For clean gas ⅝-in. O.D. tubes are used in chemical plants. ⅝-in. O.D. tubes are used with good, clean water, such as sea water. It is customary in refineries, because of the prevalence of fouling conditions, to use ¾-in. O.D. tubes for ordinary duties. For unusual fouling conditions 1-in. O.D. tubes are used. A larger tube diameter, such as 1¼-in. or 1½-in. O.D. is used only when the pressure drop is excessive and the larger tube is required to reduce it.

Tubes 16 ft. long are generally used in oil refineries. Refiners prefer not to use a length greater than 16 ft. because of space limitations. An additional length of approximately 14 ft. is required to remove the tube bundle from the shell for cleaning. In the event that space limitations or pressure drop requirements dictate that a length shorter than 16 ft. be used, then the length should be either 8 or 12 ft. In chemical plants, where ground space is ample, a maximum tube length of 20 instead of 16 ft. is used.

Since orifice baffles are employed only with absolutely clean fluids, they are seldom used. Segmental baffles are almost always used in refinery heat-transfer apparatus. Disk-and-doughnut baffles are used sometimes.

The flow path through the shell is considered in working out the size of the unit, and the most suitable internal arrangement selected.

Design Practice

The designer must be familiar with the principles of mechanics and structures as well as with the art and techniques of working, machining and welding metals. When a new design is needed the designer is called upon to exercise his ingenuity to develop a form of mechanical construction which ideally should be novel, easy to handle and foolproof in operation.

API-ASME Code

The ASME Code for Pressure Vessels originated as a safety measure to insure that the external parts of all pressure vessels would be designed in a manner that would prevent the possibility of explosion, with attendant loss of life and property damage. Rules were formulated and promulgated for the design of pressure vessels which would insure sufficient thickness and strength of parts. Both the "API-ASME Code for the Design, Construction, Inspection Repair of Unfired Pressure Vessels for Petroleum Liquids and Gases," published by the American Petroleum Institute—The American Society of Mechanical Engineers, Fifth Edition, 1951; and "ASME Boiler Construction Code, Section VIII, Rules for Construction of Unfired Pressure Vessels," published by The American Society of Mechanical Engineers, 1952 ed. with 1954 addenda—contain formulas for calculating dimensions of shell, dish head, flat cover plate, tube and flange.

The materials from which Code vessels must be fabricated are required to conform to the particular physical and chemical specifications described in the ASTM Standards, which covers all Code materials. Using materials of known constant composition the Code limits the designer to using allowable stress values which are ¼ of the tensile strength; this is equivalent to using a safety factor of 4.

After the vessel has been designed reference is made to the rules set forth in the Code covering fabrication which deal with types of welding and qualifications for welders. After fabrication the Code requires that the vessel undergo a hydrostatic test at 1½ times its design pressure as evidence that it is free from leakage. A duly qualified Code inspector checks the design, the materials, the qualifications of the welders, and the hydrostatic test. When a vessel has been designed, fabricated and tested in accordance with API-ASME or ASME Code procedure, it is stamped by the inspector with the official Code symbol.

TEMA Standards

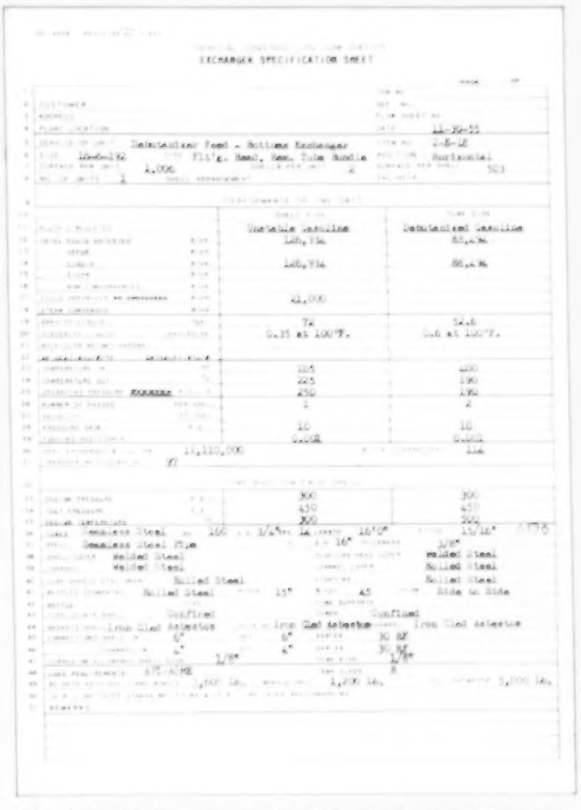
The API-ASME and ASME Codes apply to all pressure vessels including towers, tanks and heat exchangers. The Tubular Exchanger Manufacturers Association, Inc., is composed of a group of representative manufacturers of heat-transfer equipment. This group has published a booklet "Standards of Tubular Exchanger Manufacturers Association" which deals exclusively with heat exchangers. The third edition of this booklet, published in 1952, consists of 150 pages; a short addenda was issued in 1954.

This publication takes up where the API-ASME and ASME Codes leave off and contains much valuable detail about heat exchanger construction. It defines three types of mechanical construction: Class R, Class C, and Class A. Class R, whose requirements are the most rigorous, applies to heat-transfer equipment for use in petroleum refineries; Class C, which is less exacting, applies to similar equipment in applications where the requirements need not be so demanding—for general applications. Class A deals with expensive alloys, such as stainless steel, in which consideration is given to using thinner parts than would be used if steel were used. This article is confined to TEMA Class R construction.

TEMA Class R mechanical standards specify design pressures of 75, 150, 300, 450 and 600 psi as standard. A corrosion allowance of ⅛-in. is to be used on all steel parts. The minimum thickness of tube, shell, baffle, support plate, tubesheet and channel cover are specified. Tube length and spacing are specified, as are tube support spacing and the minimum and maximum limits of baffle spacing. Clearances between baffle and shell and between baffle and tube are given. Tables of dimensions for hub flanges designed in accordance with the API-ASME Code, covering diameters from 8 to 42 in. and pressures of 150, 300, 450 and 600 psi, are listed.

Oil Company Specifications

Some of the large oil companies accord detailed consideration to their heat-exchanger requirements. They set up their own construction standards. In some cases these



EXCHANGER SPECIFICATION SHEET

	Unstable Gasoline	Debutanized Gasoline
	140,936	82,436
	140,936	82,436
	42,000	
	72	32.6
	0.35 at 100°F.	0.6 at 100°F.
	105	400
	265	190
	450	190
	1	4
	10	10
	11,110,000	116
	300	300
	450	450
	300	300
	3/4-in.	10 ft
	16"	3/8"
	Welded Steel	Welded Steel
	Welded Steel	Rolled Steel
	Rolled Steel	Rolled Steel
	Rolled Steel	Side to Side
	Baffles	Baffles
	Iron Clad Asbestos	Iron Clad Asbestos
	6"	30 BF
	4"	30 BF
	1/8"	1/8"
	3/4-in. OD	

Fig. 57—Exchanger specification sheet completely describes any type needed for a special purpose

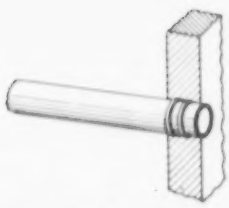


Fig. 58—Rolled tube joint is the most common form of fastening tubes in tube sheet

Courtesy of Alco Products, Inc.

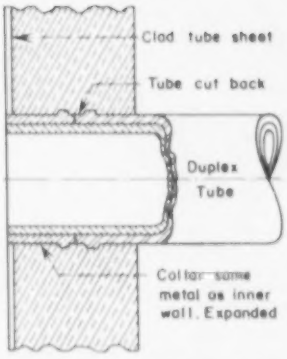


Fig. 60—For bimetallic tubes, special measures must be taken in joining the tubes and tube sheet

Courtesy of Bridgeport Brass Co.

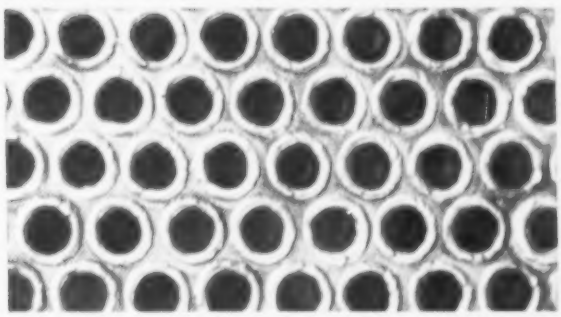


Fig. 59—Welded tube joints remain tighter than a rolled joint when considerable expansion occurs

Courtesy of Alco Products, Inc.

are quite detailed and impose additional requirements beyond those covered by the API-ASME Code and impose additional requirements beyond those covered by the API-ASME Code and TEMA Class R. These are extra requirements which, from experience, have been found desirable but which the manufacturer ordinarily would not furnish unless requested to do so.

Exchanger Specification Sheet

It is the custom of manufacturers of heat-transfer equipment to set forth a description of the exchanger which they propose to furnish on an Exchanger Specification Sheet similar to that shown in Fig. 57. The engineer who requires a heat exchanger for his process should fill out on this sheet the operating conditions regarding rates of flow, temperatures of the hot and cold media, amounts of vaporization or condensation—if any, and operating pressures and allowable pressure drop (lines 5 and 6, 11-25, and 28-30).

The process engineer should list the properties of substances whose values are not in published handbooks—if he knows them. In addition, if the customer has preferences as to kind of material, tube size and length or any other pertinent information, they should be noted on the Specification Sheet (lines 36-48) for the information and guidance of the designer. When TEMA Class R construction is called for by the customer it sets the tube length at 16 ft, and the corrosion allowance at 1/8-in. on all steel parts. Fouling factors for typical materials are listed in the TEMA Standards. TEMA Class R requires also that the channel and floating-head cover be stress relieved.

With this information the designer is in a good position to work out a unit capable of the required performance. After making his selection, the designer completes the Specification Sheet, which will then look like the one shown in Fig. 57.

Materials of Construction

The selection of suitable materials for oil refinery heat exchangers is a simple problem because operating conditions generally are not extreme. Oil-to-oil exchangers are usually fabricated entirely of steel. Water-cooled condensers and coolers employ admiralty tubes and naval-rolled-brass tubesheets with all other parts of steel. When salt water is used for cooling, steel is not resistant enough and the channel, channel cover and floating-head cover have to be fabricated from cast iron, bronze or monel. Brass composition cannot be used at temperatures over 400°F. Steel, admiralty and brass are suitable for most exchangers.

At temperatures above 800°F. the low-alloy steels, containing 1 to 4% Cr Mo, are used because of their greater strength at high temperature and their resistance to corrosion. At higher temperatures and for severe cor-

Fig. 61—Packing at the baffle edge prevents bypassing of shell fluid and allows removal of baffle

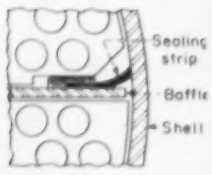


Fig. 62—For small pressure differential between shell passes, baffles may be sealed by stainless steel strips

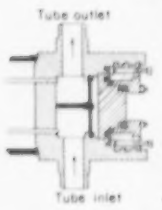


Fig. 63—For high pressure service the shear ring type of closure is used

Courtesy of A. O. Smith Corp.

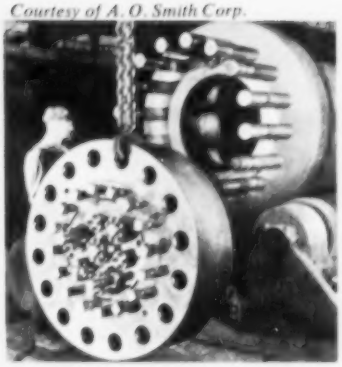


Fig. 64—A special closure for extremely high pressure use (up to 10,000 psi) is called the Bridgeman closure

Courtesy of C. F. Braun & Co.

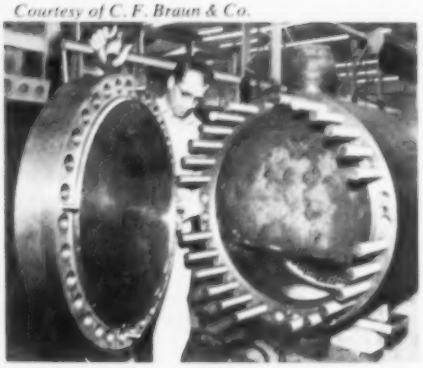


Fig. 65—Another type of closure for extreme pressures is the Delta Ring

rosion stainless steel may be used. At the other end of the temperature scale Ni steel is used down to temperatures of —100°F. Copper, aluminum and stainless steels are utilized at temperatures as low as —280°F.

In a petrochemical plant it was desired to use admiralty tubing on the water-cooled units. However, the shell-side material acted upon admiralty. In order to withstand the different corrosion conditions which existed on each side of the tube, bi-metallic tubes—made by expanding an inner admiralty tube into an outer steel tube to form a metal bond—were used.

It has frequently been the practice when steel has been found to be unsuitable to go to stainless steel, which is very costly. However, aluminum is being made increasingly available recently and, because of its resistance to many types of corrosion, it is finding increasing use in heat exchangers. The cost of aluminum is low, falling between that of steel and brass.

Design Features

Tube Attachment to Tubesheet

In most instances tubes are fastened to tubesheets by the mechanical bond illustrated in Fig. 58. Two grooves each 1/8-in. wide and 1/64-in. deep are machined in the tube hole of the tubesheet—into which the tube wall is expanded. After repeated expansion and contraction during operation the tubes may work loose from this bond to the tubesheet. Under severe operating conditions it may be decided to weld the tubes to the tubesheets to insure a stronger bond. Fig. 59 is a photograph of tubes seal-welded to a tubesheet.

When one of the two fluids flowing through a heat exchanger is corrosive, bimetallic tubes are often used. When cooling with salt water admiralty metal is suitable for the tubes. But if the shell fluid attacks admiralty but not steel then bimetallic tubes—made of admiralty inside and steel outside—are used. It is necessary also to protect the channel face of the steel tubesheet from salt water by cladding it with a thin sheet of brass. A duplex tube rolled into a clad tubesheet is shown in Fig. 60, where the end of the steel tube has been cut off and replaced by a brass collar. This prevents galvanic action between steel and brass at the inside face of the tubesheet.

Baffles

Impingement baffles are always used when vapors at high velocity, carrying entrained liquid droplets, pass through the shell. The impingement baffle is a disc slightly larger than the nozzle opening and is located just below the shell inlet nozzle to cover and protect the tubes from erosion. It must be located far enough away from the shell that flow is not choked up at that point.

If a longitudinal baffle is used in a two-pass shell it must fit tightly against the enclosing shell. If it does not, then the shell fluid will bypass around the edge of this baffle. At the same time, since it is part of the tube bundle, it must be removable from the shell when required. The best means of accomplishing this is to use packing at the baffle edge. (Illustrated in Fig. 61.)

While packing effectively seals the clearance between shell and longitudinal baffle sometimes it sticks and cannot be removed when the bundle is pulled from the shell. Another means of sealing the clearance between shell and longitudinal baffle is to attach a number of strips of stainless steel to the top side of the longitudinal baffle so that they spring against the shell as shown in Fig. 62. Its use is limited to cases where there is only a small pressure differential between the two shell passes. Because of the innate limitations of the sealed longitudinal baffle some refineries will not use them, preferring instead to use two single-pass shells.

Closures

Were it certain that a heat exchanger would never foul up—so that access to the inside and outside of the tubes would be unnecessary—the whole thing could be welded together. However, in oil refineries fouling is a common condition and for this reason exchangers must be put together so that they can be taken apart. This requires the use of bolted and gasketed flanges at locations where openings are required.

The pressures at which petroleum is processed generally do not exceed 600 psi, for which condition the conventional bolted flange type of closure is satisfactory. In platforming plants, operating at 600 to 800 psi, simple U-tube construction has replaced the floating-head type. Boiler feedwater heaters in power plants operate at pressures up to 3,200 psi. From 900 to 3,200 psi they utilize the shear ring type of closure shown in Fig. 63. In this construction the hydrostatic load is not sustained by bolts but by shear on a ring inside the head. By this means massive flanges and bolting are avoided.

Operating pressure in a petrochemical plant may run as high as 10,000 psi. There are two types of closure which are used to withstand high pressures, the Bridgman closure illustrated in Fig. 64 and the Delta Ring pictured in Fig. 65.

Typical Duties

Cooler

Tar Cooler

A TYPICAL tar-cooling duty consists of cooling a quantity of tar from the bottom of the tar stripper. The tar is required to be cooled from 875°F. to 275°F. Cooling water at 85° is allowed to heat up as high as 150°F. For this duty it was decided to employ a submerged pipe coil of the type illustrated in Fig. 2, consisting of 3-in. I.P.S. steel pipe schedule 80 (extra strong) in 20-ft. lengths. The pipe coil was used because it would not foul as quickly as a small tube and because its diameter would keep the pressure drop at a low value. With a small quantity of tar being cooled through a long temperature range a single series stream through the pipe was found sufficient. The viscosity of the tar varied considerably from inlet to outlet temperature; at inlet the flow was turbulent but by the time it reached the outlet the flow was streamline with Reynolds Number less than 300.

In calculating the coefficient of heat transfer and the pressure drop, it is necessary to break the performance into zones corresponding to turbulent flow, transition flow, and streamline flow. Since the flow quantity and cross-sectional flow area of the pipe are known, the temperature at which the tar has a viscosity corresponding to the Reynolds number equivalent to these criteria of flow can be calculated. The amount of heat transfer surface required in each zone, and the pressure drop through that zone, are calculated and added together to give the total value for the entire duty.

In calculating the heat-transfer coefficient for streamline flow inside this pipe it is necessary to take account of the additional effect of natural convection, which increases the heat-transfer coefficient calculated for forced convection. If a shell-and-tube unit were used the oil would preferably be routed inside the tubes because they are easier to clean than outside.

Cooler

Water-cooled units employed in oil refineries are all of the TEMA Class R, split-backing-ring, floating-head, removable-tube-bundle construction already described and illustrated in Fig. 17. Admiralty tubes and naval-rolled-brass tubesheets are used to stand up against the water while the remainder of the unit is fabricated of steel. Tubes are ¾-in. O.D., 16 BWG and 16 ft. long. When clean fluids are cooled the tubes are spaced on a 15/16-in. triangular spacing; for dirty and fouling liquids the tubes are spaced on a 1-in. square or a diagonal-square spacing. Fouling factors for water given in the TEMA Standards vary from 0.0005 to 0.010. In most cases of oil refinery practice it is customary to use a fouling factor of 0.003.

In petrochemical plants water apparently is regarded differently for steel tubes and tubesheets are used, the tubes being ¾-in. O.D., 16 BWG and 20 ft. long. Also, a fouling factor of 0.001 is used for the cooling water, which usually is cooling tower water. Actual design values of the overall heat transfer rate U for gasoline or naphtha coolers vary from 90 to 120 depending on whether the fouling factor used is 0.001 or 0.003. Rates for kerosine coolers are 80 to 90, and for heavy gas oil coolers U is 50.

Fuel Oil Heater

Bunker C fuel oil of high viscosity is heated from 80 to 250°F by means of steam before feeding to a burner under an allowable pressure drop of 10-15 psi. Since the oil is liable to cause severe fouling it is passed through the tubes of the unit. This fouling can be more easily removed from inside the tubes than if it were deposited outside the tubes; furthermore, with steam in the shell a close triangular tube pitch is used which permits more heat-transfer-surface in a given shell diameter. The tube interiors are made easily accessible by unbolting and removing the channel covers. Use of the fixed-tubesheet construction (already described and illustrated in Fig. 12) is possible because thermal expansion differentials are very small for two reasons: (1)—the unit is of all steel construction, and (2)—the resistance of the oil to heat transfer is such a great fraction of the total resistance that the temperature of the tube is very close to the temperatures of the shell and tubesheets. This construction is most simple and low in cost. The overall coefficient of heat transfer for this unit, using a fouling resistance of 0.01 for the Bunker C fuel oil, is approximately 20-30.

For heating fuel oil and tar, finned pipe is particularly good. Fins are advantageous here because of the great difference in magnitude of the heat-transfer coefficients between the oil and the steam; for oil the heat-transfer coefficient is approximately 30, and for steam it is 2000. Steam is placed inside the pipe where its coefficient, referred to the external surface, is 335—which is still high compared to 30. After the fin efficiency has been taken into account the overall rate, U, works out to be 15-20. Longitudinal-fin pipe is used either in the form of finned-double-pipe sections (previously described and shown in Fig. 27) or in the form of tubing in a shell-and-tube exchanger.

Exchangers

Exchangers are units in which two fluids, either gas or liquids or any combination thereof, transmit only the sensible heat involved in cooling one while heating the other. In oil refineries TEMA Class R split-backing-ring, floating-head, removable-tube-bundle construction is always used. Since both fluids are hydrocarbons, steel is adequate unless the operation is at very high temperatures or heavy corrosion is anticipated. Tubes are ¾-in. O.D., 14 BWG and 16 ft. long—unless difficulty is anticipated in cleaning inside this diameter. In that case 1-in. O.D. 12 BWG tubes of the same length are used.

For ¾-in. O.D. tubes and clean fluids the 15/16-in. triangular spacing may be used, while for fouling liquids a 1-in. square or diagonal-square spacing is employed. For 1-in. O.D. tubes and clean fluids 1¼-in. triangular spacing is used, for dirty liquids a 1¼-in. square or diagonal-square spacing is specified. TEMA fouling factors are 0.0005 to 0.01 for hydrocarbon fluids.

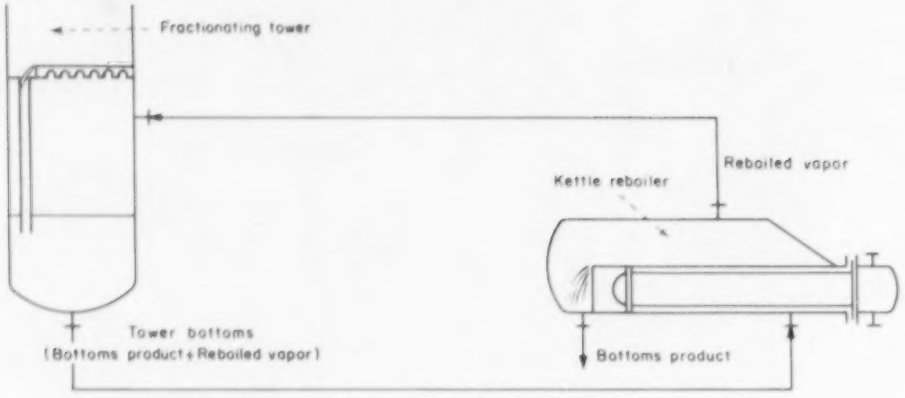


Fig. 66—A typical arrangement for using a kettle-type reboiler

The overall rate of heat transfer in oil-to-oil exchangers can vary over the range of 120 to 12 depending on the material. The lightest fractions having the lowest viscosity yield the highest coefficients of heat transfer. For example, in a gasoline-to-gasoline exchanger U will be between 100 and 120 depending on the fouling factors used; in an asphalt to reduced crude exchanger U will be 12 to 15.

Vaporizers

Vaporizer

Any baffled shell-and-tube exchanger can be used for vaporization—occurring either in the shell or in the tubes. When vapor is generated there is a great increase in volume. Since the pressure is inversely proportional to density and directly proportional to volume, flow areas must be increased to keep the increased pressure drop (resulting from vaporization) within limits.

Where vaporization accounts for 20% or less of the total heat transferred in the exchanger, the coefficient of heat transfer may be calculated as for a liquid. For a boiling hydrocarbon the coefficient of heat transfer will be between 150 and 300, probably nearer the higher value. It is high because the viscosity of the liquid at its boiling point is quite low. The overall rate is governed by that of the heating fluid which is not as high; for instance, the viscosity of the heavy fluid even at a high temperature may still be appreciable or when the hot fluid is a gas or vapor the rate could be fairly low.

Because of the wide variety of materials which could be used for heating, values of U could vary over a considerable range. The remarks made about materials of construction, style of construction, tube sizes and spacing and fouling factors for exchangers apply here also. If vaporization occurs in the shell, square tube pitch is usually employed to allow for vapor liberation and cleaning. For hydrocarbon fluids steel is used.

Kettle Type Reboiler

The kettle-type reboiler has already been briefly described. A type employing straight tubes was illustrated in Fig. 23. The straight tubes, removable shell cover and channel with removable cover are required when an oil is used for heating. The tubes are made accessible for cleaning inside and outside by removing the tube bundle from the shell and unbolting the floating-head cover. This construction is similar to the pull-through, floating-head style illustrated in Fig. 16 and requires that the shell opening be 3 to 4½-in. larger than the outside diameter of the tube bundle itself. Square tube pitch is used for liberation of vapor and to provide accessibility for cleaning outside the tubes. Fig. 66 is a diagramatic sketch of the flow in and out of this reboiler.

The coefficient of heat transfer for a boiling hydrocarbon is close to 300 but the overall U will be governed by the heat-transfer coefficient of the oil in the tubes which, in turn, depends largely on its viscosity. For oil-to-oil service all the parts are steel. When steam is used as heating medium the construction has been illustrated in Fig. 22 with U-tube floating head and bonnet. The use of U-tubes reduces the shell opening required for the tube bundle and also the shell diameter. These factors—U-tube floating head, bonnet, smaller shell diameter and smaller shell opening—all have their effect in reducing the cost of the unit below that of the straight-tube type for the same size tube bundle.

In steam-heated hydrocarbon reboilers the overall U varies from 100 to 120. The design U for a steam-heated monoethanolamine reboiler, used in the gas purification process for CO_2 removal, is 250. Because of the corrosive action of MEA solution on steel, stainless steel tubes and tubesheets are sometimes used for this application. Flow in the kettle-type reboiler is once-through, with the bottoms product of the distillation being withdrawn as overflow from the reboiler and the reboil heat passing to the tower in the vapor.

Thermosyphon Reboiler

Horizontal

A horizontal thermosyphon reboiler is sketched diagramatically in Fig. 67. A liquid level (h_l) is maintained in the distillation column, and tower liquid flows into the shell of the reboiler. As heat is imparted to the tower liquid in the reboiler it begins to vaporize. Since the mixture of vapor and liquid has a lower density than liquid alone a pressure differential is set up between the liquid head (h_l) and the vapor-liquid head (h_{l-v}). Since h_l is greater than h_{l-v} the fluid begins to flow as a consequence of this thermosyphon effect.

Flow is opposed by the pressure loss developed in flow-

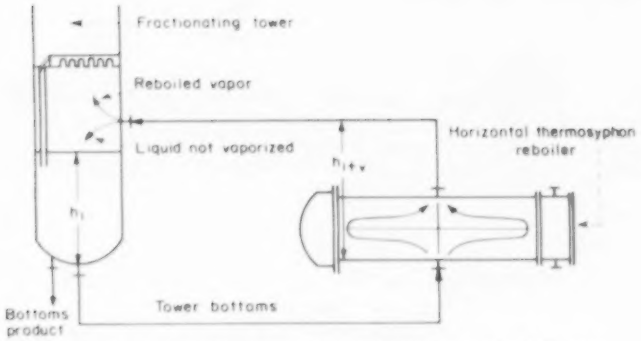


Fig. 67—A horizontal thermosyphon reboiler operates like this

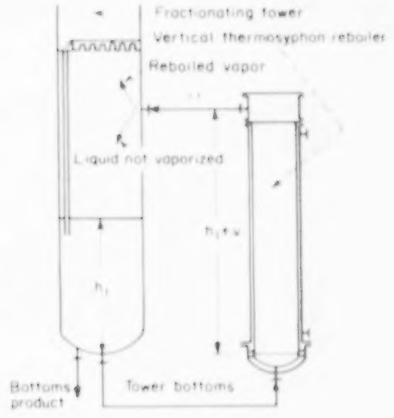


Fig. 68—A vertical thermosyphon reboiler operates like this

ing through the reboiler and the lines leading to and from it. When the rate of flow caused by the difference in h_i and h_{i+v} is calculated it will be found that the rate of continuous recirculation is very high; the liquid may be flowing through the reboiler at perhaps 30 times the rate of flow at which the bottoms product is being withdrawn from the tower.

It will be noted that the shell flow arrangement is similar to that shown in Fig. 10-E for split flow. Double-split flow similar to that shown in Fig. 10-F may also be used, if desirable. A dome space above the tube bundle, equal in cross-sectional area to that of the outlet nozzle, is provided to allow the vapor-liquid mixture room to issue from the unit. In horizontal thermosyphon reboilers a tube length of 8 ft. is sometimes used to reduce the pressure drop.

Vertical

A vertical thermosyphon reboiler connected to a fractionating column is shown in Fig. 68. Tower liquid flows upward inside the tubes of the reboiler, where it is partly vaporized, and the mixture of liquid and vapor rises to the channel from which it flows back to the tower. The need for single-pass tubes requires that a packed-slip-tube, floating head be used. As mentioned earlier this type of construction is suitable when steam is the heating medium in the shell.

The vertical height of the reboiler requires that the lowest plate in the tower be located above the channel outlet of the reboiler. This is accomplished by raising the bottom plate in the tower, by increasing the height of the skirt supporting the tower, or by using a shorter length of tube in the reboiler. The same remarks made about kettle-type reboilers regarding materials of construction and overall rates apply also to thermosyphon reboilers. Either type of thermosyphon reboiler costs less than the kettle-type because of its smaller shell.

Steam Generator

The steam generator already illustrated in Fig. 10-I is employed to utilize the heat in a hot oil stream, which otherwise would be wasted and would also entail the expense of providing a cooler and cooling water to cool down the oil or tar. When badly fouling tar is used, the usual type of tube bundle may be inadequate, for the small channel areas in a multi-pass unit may plug. For such cases the tubes are joined in paths by means of individual streamline return-bend-tube-connector headers, similar to those used in tube stills. These headers are removable and facilitate cleaning inside the tubes. However, the use of such headers requires that the tubes be spaced relatively far apart, thus increasing the size of the unit.

Purification of the steam is accomplished in this unit by means of the disengaging area resulting from having the shell only half filled with water, and by use of a moisture separator which may be either the dry pipe previously mentioned or a more efficient centrifugal type. While the coefficient of heat transfer for boiling water under pressure is taken as approximately 1000, the heat-transfer coefficient of the oil inside the tube is much lower and sets the overall rate.

Waste-Heat Boiler

In chemical and petrochemical plants, the heat in reaction gases is reclaimed in waste-heat boilers. The gas flows through the tubes of a fixed-tubesheet unit, the shell of which is filled with water. The water, which is partly vaporized, passes to a disengaging drum in which the steam is separated. Flowing in a single pass through the tubes, the gas transfers heat by forced convection; but, at temperatures over 600°F., the effect of heat transfer by radiation should also be taken into account. The coefficient of heat transfer for the gas will vary with its pressure and the allowable pressure drop. For pressures to 100 psig. with an allowable pressure drop of 1-2 psi, the over-all U will be within the range of 15 to 20.

Condensers

If the overhead vapor from a fractionating tower is at a high temperature, it may be advisable to utilize the high-level heat in the vapor to preheat the feed stream by partial condensation of the vapor. However, it is always necessary in condensing an overhead vapor down to the storage temperature of 100°F. to use water as coolant.

Water-cooled condensers are TEMA Class R construction of the split-backing-ring, floating-head, removable-tube-bundle style. Tubes are ¾-in. OD., 16 BWG, admiralty and 16-ft. long. Triangular spacing of the tubes on 15/16-in. pitch is ordinarily used, unless serious fouling is anticipated. Then, 1-in. square pitch is called for. Naval-rolled-brass tubesheets also are used and the remaining parts are of steel. (The possible types of shell baffling have been illustrated in Fig. 10-E-G; methods for

distributing the vapor to the heat-transfer surface were sketched in Figs. 25, 26, and 10-J).

An important requirement in the design of a condenser is ample dome area at the inlet to the tube bundle and also at the outlet from it. In oil refineries, all condensers are installed in a horizontal position. If located on an overhead platform, sufficient clearance space must be allowed to withdraw the tube bundle. In horizontal installations, the vapor is always in streamline flow and the coefficient of heat transfer for condensing vapor is calculated from the Nusselt relation.

Pure Vapor Condensation

By pure vapor is meant a single compound which will condense at a given temperature corresponding to the operating pressure, such as pentane which condenses at 140°F. at a pressure of 15 psig. The condenser is water-cooled and the over-all heat-transfer design rate U ranges between 90 and 115, depending on the fouling factor used.

Condensing Gasoline

A common condensing duty for atmospheric crude distillation is that of gasoline, steam and non-condensable gas at 3-5 psig by means of cooling water. The vapors leave the tower at approximately 250°F. and are required to be condensed and cooled to 100°F. A pressure drop of 2 psi is allowed. The gasoline vapor has, of course, a variable condensing temperature and begins to condense just below 250°F. Gasoline vapor condenses from 250 to about 155°F., at which point all the steam comes out of it—condensing within about 5°F. Then, the remaining vapor is condensed, to 100°F., while at the same time the condensate is cooled to the outlet temperature.

In this condensation, the quantity of heat removed is not directly proportional to the temperature drop. Since the logarithmic MTD is based on this premise, the logarithmic MTD calculated from the terminal temperatures is not applicable and cannot be used. Instead, the MTD must be broken down into a number of components, for which each component's logarithmic MTD would be approximately correct. These component MTDs are then combined to give a weighted effective MTD. Condensation is slowed down by the presence of the inert gas and overall U = 60-70.

Debutanizer

An example of a light-ends condenser is the condensation of butane and lighter vapors at 150 to 100°F. Under pressure of 190 psig, 96% of the vapor will condense through this range; water is used as the cooling medium. The over-all coefficient of heat transfer U is 60, using a fouling factor of 0.003 for the cooling water.

Vapor with Non-Condensable Gas

When a vapor condenses from a mixture, in which a non-condensable gas is present, the condensing rate is much lower than for pure vapor alone since the vapor must diffuse through an inert gas to reach the cold surface of the condenser tube. The most important condition influencing the mechanism of mass transfer, which precedes condensation, is the pressure on the system.

For the same composition mixture of vapor and gas, condensation at a higher pressure produces a higher heat-transfer rate; condensation at a lower pressure produces a lower heat-transfer rate. The reason for this is that mass transfer is greatly aided by the increased gas velocity permissible at higher-pressure operation due to the greater vapor density. Also, the pressure drop permitted at high pressure may be 5 to 10 psi, compared to a few millimeters of mercury under vacuum operation.

Another factor which makes its effect felt when hydrocarbon vapors are condensed is the viscosity of the condensate as it affects the Nusselt heat-transfer coefficient of condensation. The oils with lowest viscosity (butane, propane, etc.) are condensed under pressure. Both of these factors—low viscosity and high pressure—are conducive to high condensing rates.

At the other end of the pressure range, lubricating oil distillate, vacuum distilled at a pressure of 60 millimeters of mercury, will have a low condensing rate because its viscosity is high and the vapor velocity in the condenser is low. For this duty, the condensation of heavy oil under vacuum, U will be within the range of 25 to 35.

When steam is condensed from a mixture of steam and a non-condensable gas (H_2S or CO_2) at atmospheric pressure, the over-all rate of condensation is reduced by the presence of the inert gas to just about half what it would be if steam alone were present.

Vertical Condenser-Subcooler

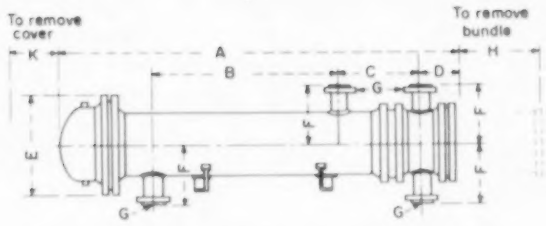
To subcool a condensed vapor in the same unit, the best way is to use a vertical unit where the vapor and cooling water flow in opposite directions. In order to obtain true counterflow a single-pass shell—with single-pass tubes of the packed-slip-tube, floating-head construction shown in Fig. 21—is needed. The vapor will pass down inside the tubes while the water flows up through the shell. Condensing rates are calculated from the Nusselt relation and subcooling rates have been obtained which vary from approximately 50 to 80% of the condensing rate. In operation, if the vapor velocity through the tube is high, it will blow the condensate down the tube, reduce film thickness, and increase the coefficient of heat transfer.

Horizontal Condenser-Subcooler

In oil refineries, the condensing range, through which vapors of successively lower boiling point condense, is sometimes several hundred degrees. If the high-boiling components dropped from the shell, they would not be subcooled to the required outlet temperature of 100°F. When the overhead condenser installation is large—consisting of two or three shells in series—the condensate has a good chance of being subcooled because its vertical travel path is long; and, it is kept in contact with cold condenser tubes for a sufficient length of time to effect subcooling. However, in a small tube bundle which may be only a foot high, this is not the case. To insure that the condensate is subcooled, the bottom of the tube bundle can be flooded by a pool of condensate.

Condensate subcooling takes place at a natural-convection rate, which for hydrocarbon oil would be 50 to 60. The calculation of the MTD in this unit is complicated by the fact that in a multi-pass tube unit, true counterflow does not exist. However, the heat-transfer surface required for condensation and for subcooling is computed, and the sum of these comprises the total surface required in the unit.

To retain a liquid level, the dam baffle already described and illustrated in Fig. 10-I may be used. Other methods of flooding the lower tube-bundle are to place the shell outlet nozzle higher up on the shell so that condensate has to overflow to pass through it. Or, to put a U-leg in the condensate pipe line leaving the shell, which will maintain a liquid level at any predetermined height.

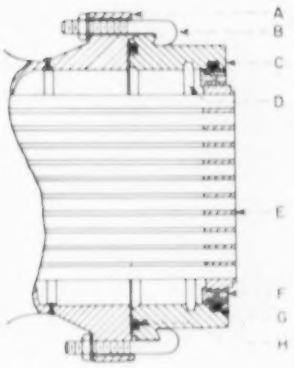


Exchanger Dimensions and Weights

Unit Size*	A	B	C	D	E	F	G	H	K	Estimated Weight Bundle Empty	Full	
in.	ft-in.	ft-in.	in.	in.	in.	in.	in.	ft-in.	in.	1000 lbs		
10	18-2½	14-2½	16	9⅞	18¾	12	3	14-10	10	0.6	2.0	2.5
12	18-3	14-2	16	9⅞	20¾	13	3	14-10	10	0.7	2.3	3.4
14	18-5½	14-0	18	11	22¾	14	4	14-7	11	0.9	2.9	4.0
16	18-6	13-11½	18½	11	24¼	15	4	14-7	11	1.2	3.6	5.0
18	18-10	13-10	21	12¾	27½	16	4	14-3	12	1.6	4.3	6.4
20	18-11	13-7	22	13	29½	17	6	14-3	12	2.1	5.5	7.7
22	19-2	13-6	23	14	31⅝	18	6	14-1	13	2.5	6.5	9.4
24	19-2	13-5½	23	14	34⅛	19	6	14-1	13	3.0	7.7	10.8
26	19-5	13-2	25½	14½	36⅛	20	8	14-0	14	3.7	9.2	12.7
28	19-6	13-1	26	15	38⅛	21	8	14-0	14	4.3	10.6	14.7
30	19-10	13-0	28	16½	40⅜	22	8	13-8	15	5.0	12.6	17.0
32	20-0	12-10½	29	17¼	42⅜	24	8	13-7	16	5.7	14.5	19.6
34	20-1	12-9½	29½	17½	44½	25	8	13-7	16	6.6	16.6	22.7
36	20-2	12-8½	30	17½	46⅞	26	8	13-7	16	7.7	18.9	26.4
38	20-8	12-5½	33½	20	49⅞	27	10	13-2	16	9.0	21.5	29.1
40	20-10	12-3½	35	21	52⅛	28	10	13-1	17	10.7	24.0	32.6

*Unit Size is nominal shell diameter

Fig. 69—Use of this sketch and table permits dimensioning for installation of typical units



A- Shell-Flange
B- Hook-Bolt and Nut
C- Test-Set Body
D- O-Ring Groove for 300-
E- and 450-Pound Tubesheets
F- 150-Pound Floating-Tubesheet
G- Bolt-Hole Stopper with O-Ring
H- Rubber O-Ring in the Groove
I- for 150-Pound Tubesheets
J- Rubber O-Ring in the
K- Shell-Flange Groove

Fig. 70—A test ring will aid in locating a leak

In the Plant

Installation

GROUND foundations must be adequate to support the weight of flooded units. When condensers are installed near the top of a tower, structural platforms must be designed to support the load, and also provide sufficient room to remove the tube bundle from the shell. For all installations, clearances are required at both ends of the exchanger to provide sufficient room for dismantling. At the channel end, a length of about 2 ft. less than the tube length, which would be 14 ft. for 16 ft. tube bundles, is required to withdraw the tube bundle from the shell. At the floating-head end, 3 or 4 ft. are required to remove the shell cover and the floating-head cover.

The exchanger must be set high enough above the ground to allow pipe lines and elbow connections to come in under the unit where they are attached to the shell and channel flanges. Sufficient space has to be allowed also between parallel shells to give sufficient room for any insulation and pipe lines. The unit should be inspected before piping-up to insure that all extraneous material has been removed and that it is in a clean condition. A table of over-all dimensions and weights of TEMA Class R 300-lb. exchangers is shown with Fig. 69.

Operation

A unit is put into operation by first circulating only the cold medium. All air is vented from the unit by filling it slowly with fluid, until it overflows the vent connection located at the top. Then, the same procedure is followed with the hot medium. After the unit is operating and has become heated, the bolting is checked for tightness.

To shut down, the flow of hot fluid is first gradually shut off, then the cold fluid is shut off. Cold fluid should never be shut off while the hot fluid is flowing because brass tubesheets are designed for operating temperatures which are less than the temperature of the hot fluid. All liquids must be completely drained from the unit as protection against freezing and corrosion. The last remaining portions are run out from the drain connections located at the bottom of the unit.

Maintenance

Fouling

When performance drops off considerably from initial operating performance, it indicates that heavy fouling has set in. Instances are even known where heavy fouling deposits occurred at startup in the channel and tubes. For when flow started, all the pipe-line scale was flushed along and filtered out by the exchanger heads and tubes. But usually fouling builds up gradually. Often it is unpredictable and variable. When performance has dropped off so badly that the process is adversely affected, then the unit must be shut down and the tube bundle cleaned. If shutdowns for cleaning are frequent, it may be worthwhile having a spare tube bundle on hand.

Dirt may be dislodged from the tube lanes between square-pitch tubes by manually working flat bars or saws back and forth. If this is not effective, sandblasting can be used. To flush out the tubes, a stream of hot water can be tried. Rotary tube cleaners also can be used. In extreme cases, hard-water scale has become so firmly imbedded that drilling may be used. If the fouling deposit outside the tubes dissolves in a suitable solvent, a solution of inhibited acid or other solvent is pumped through the shell of the unit, which need not be dismantled.

If chemical cleaning is not satisfactory, then the tube bundle must be removed from the shell to permit access to the outside tube surface. If the tube bundle is lowered to the ground from an overhead location, it should be supported in a sling or cradle in order to distribute the area on which the load rests. Great care is required in removing the tube bundle because the tubes are the thinnest part of the exchanger. For example, a 16 BWG tube is 0.065 in. thick—while the minimum thickness of any other part of the exchanger is ⅛-in. A 24-in. tube bundle weighs 3,000 lbs. The tube bundle is removed by screwing an eye bolt into the top of the stationary tubesheet. Then, a chain hoist is connected to the eye to pull the bundle.

Leaking Tubes

When a unit is first built, the tubes are tested tight. After continuous use, during which the unit is subject to thermal stresses, some tubes may work loose from the tubesheet. This causes leakage from shell to tube; or vice-versa, resulting in contamination of one of the fluids. The easiest and quickest way to remedy this defect, if only a few tubes are leaking, is to close them by hammering a tapered plug into each end. This closes the hole in the tubesheet and stops leakage. Of course, the tube is of no further value for transferring heat.

If the location of a leak is unknown, then a test ring is used to locate it. (See Fig. 70). The shell cover, floating-head cover and backing ring are removed from the unit. The test-ring flange is bolted to the shell-cover flange. Then, the gland flange is bolted on to form a packed-floating-head joint for the floating tubesheet. The test ring enables the shell to be put under hydrostatic pressure while the floating tubesheet is exposed to view.

Corrosion

In many refineries, heat exchangers are inspected during shutdown for evidences of corrosion. This attack may be severe, as in the case of one overhead condenser where corrosive vapors ate through the impingement plate located at the shell inlet. Measuring the thickness of the shell at various spots—particularly near nozzles—indicates the rate at which certain areas are wearing away.

THE first series of charts, consisting of Figs. 71 through 79, covers typical refinery exchangers and is based on API-TSME, TEMA Class R construction. In these charts, the cost in dollars per sq. ft. of heat-transfer surface is plotted against the total amount of heat-transfer surface per shell. The diameter of shell necessary to enclose a required amount of heat-transfer surface, when the tube length is 16 ft., is shown in Fig. 79 for ¾-in. tubes on 1-in. square pitch. Price charts 71-76 deal only with all-steel construction

Fig. 76 shows how the use of other materials affects cost, and Fig. 77 shows the increase in cost at higher pressures, resulting from the increased thickness of parts. When a packed longitudinal baffle is employed to make the shell two-pass (as shown in Fig. 10-D), the additional cost for this baffle will vary with the diameter of the unit as shown in Fig. 78.

In earlier descriptions of the pull-through, floating-head construction (illustrated in Fig. 16) it was pointed out that the diameter of the circle enclosing the tube bundle was smaller than for any other type of construction, in the same shell size. When pricing these units, first use either Fig. 71 or 72, whichever is applicable; then, add the extra cost from Fig. 78 for pull-through, floating-head construction.

Prices for U-Tube, Kettle-Type Reboilers (illustrated

TABLE 2—Cost of U-Tube Kettle Reboilers (Fig. 22)

Surface sq. ft.	Shell diam. in.	Bundle diam. in.	Weight lbs.	Price $	Price $/sq.ft.
15	18	6	750	917	61.1
30	18	8	900	1014	33.8
50	24	10	1300	1190	23.8
100	24	10	1900	1300	13
150	30	12	2650	1660	10.8
200	30	14	2950	1900	9.5

NOTE: All steel, ASME & TEMA, 200 psig, ¾-in. O.D., 16 BWG tubes on 1-in. square pitch. Information courtesy Whitlock Mfg. Co.

TABLE 3—Prices for Special Exchangers

Size*	Surface sq.ft.	Overall Dimensions in.	Weight lbs.	Price $	Price $/sq.ft.
		(Lantern Gland—Fig. 15)			
6-5-60	25	10½ x 72	300	568	22.7
6-5-72	29	10½ x 84	340	596	20.6
6-5-84	34	10½ x 96	380	620	18.2
8-5-60	49	12½ x 72	590	759	15.5
8-5-72	59	12½ x 84	645	832	15.4
8-5-84	69	12½ x 96	700	896	13
8-5-96	79	12½ x 108	750	960	12.1
10-5-72	102	14⅝ x 84	825	1104	10.8
		(U-Tube—Fig. 14)			
6-5-60	25	10½ x 64	285	512	20.5
6-5-72	29	10½ x 76	315	544	18.8
6-5-84	34	10½ x 88	345	572	16.8
8-5-60	49	12½ x 68	545	692	14.1
8-5-72	59	12½ x 80	605	760	12.9
8-5-84	69	12½ x 92	630	830	12
8-5-96	79	12½ x 104	650	900	11.4
10-5-72	102	14⅝ x 80	725	1008	9.9

NOTE: ¾-in. O.D. Admiralty tubes, Naval brass tubesheets, remainder is steel or cast iron.
*Size designation: 1st figure is shell diam. in inches, 2nd figure is tube diam. in ⅛ inches, 3rd is tube length in inches.

Costs

in Fig. 22), are listed in Table 2, and Table 3 lists prices for small exchangers ranging from 25 to 102 sq. ft. of heat-transfer surface. Prices for two different types of construction are given: the packed, floating head (Fig. 15), and the U-tube (Fig. 14). When Tables 2 and 3 are compared with Figs. 71-75, it will be noted that the price per sq. ft. of heat-transfer surface soars as units become smaller.

All prices given so far have been for bare tubes. Turning to extended surface, it is found that the cost of tank suction heaters using longitudinally finned pipe for heating oil, tar and asphalt range as shown in Fig. 80. These units are Type 2N6, consisting of flanged bonnet, open-end insertion type shell (shown in Fig. 10-N) and U-tube floating head. Pipes are finned along their straight length, leaving the U-bends bare. These heaters are shown in three fin lengths: 124, 186, and 248 ins. The shell diameter corresponding to surface for each of the three lengths is shown in the lower part of Fig 80.

The finned, double-pipe exchangers described earlier (Figs. 27 and 28), in which the external heat-transfer surface is 100 sq. ft., are widely used. Costs run as follows:

Material		Cost
Inner Pipe & Fins	**Shell**	**$/sq.ft.**
Steel	Steel	2.5
Admiralty	Steel	3.5
304 Stainless Steel	Steel	6.0
Monel	Steel	7.0
304 Stainless Steel	304 Stainless Steel (Sch. 10)	13.0

For Fin Fan installations employing tubing with transverse fins—when admiralty tubes are used with copper fins—costs range from $0.55 to 0.85 per sq. ft. of heat-transfer surface, depending on tube size and header construction. When aluminum fins are used, these costs decrease to $0.35 to 0.65 per sq. ft.

Courtesy of Western Supply Co.

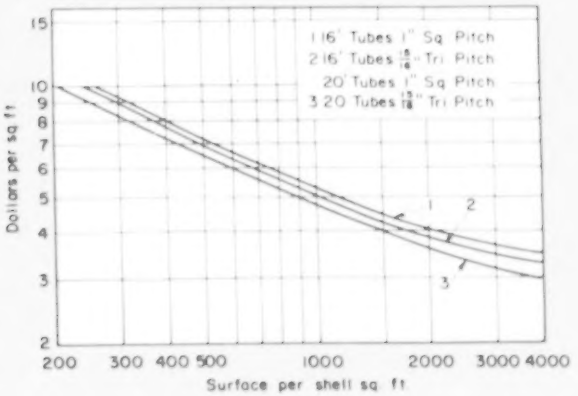

1 16' Tubes 1" Sq. Pitch
2 16' Tubes 15/16" Tri. Pitch
20' Tubes 1" Sq. Pitch
3 20' Tubes 15/16" Tri. Pitch
Dollars per sq. ft.
Surface per shell sq. ft.

Fig. 71—Prices for floating head-exchangers, made of steel, ¾-in. tubes

Courtesy of Western Supply Co.

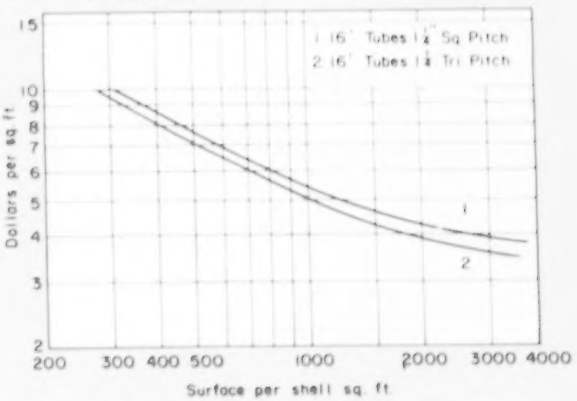


Fig. 72—Prices for floating-head exchangers, made of steel, 1-in. tubes

Courtesy of Western Supply Co.

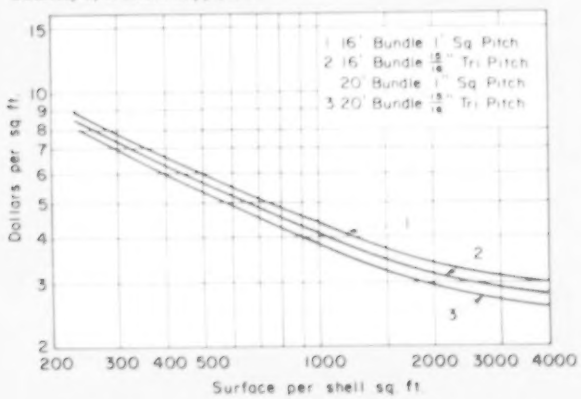

1 16' Bundle 1" Sq. Pitch
2 16' Bundle 15/16" Tri. Pitch
20' Bundle 1" Sq. Pitch
3 20' Bundle 15/16" Tri. Pitch
Dollars per sq. ft.
Surface per shell sq. ft.

Fig. 73—Prices for U-tube exchangers, steel, ¾-in. tubes

Courtesy of Western Supply Co.

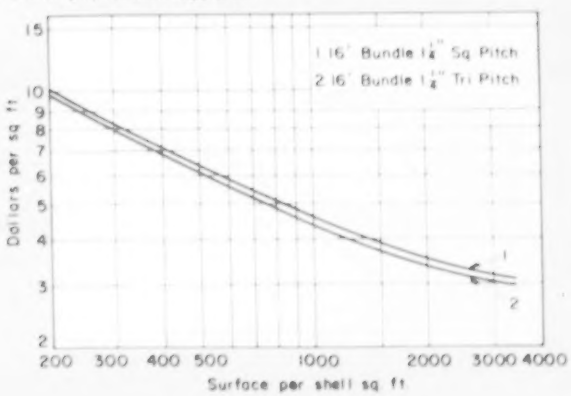


Fig. 74—Prices for U-tube exchangers, steel, 1-in. tubes

Courtesy of Western Supply Co.

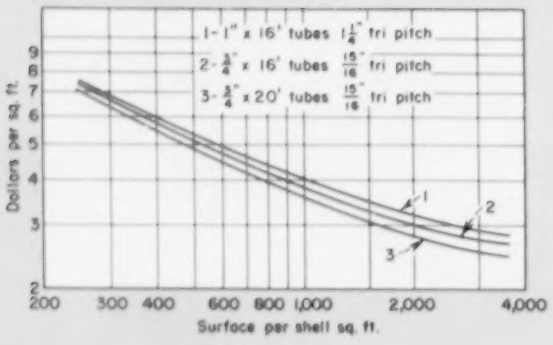

1-1" x 16' tubes 1¼" tri pitch
2-¾" x 16' tubes 15/16" tri pitch
3-¾" x 20' tubes 15/16" tri pitch
Dollars per sq. ft.
Surface per shell sq. ft.
200 300 400 600 800 1,000 2,000 4,000
1
2
3

Fig. 75—Prices for fixed tube sheet exchangers, steel

Courtesy of Western Supply Co.

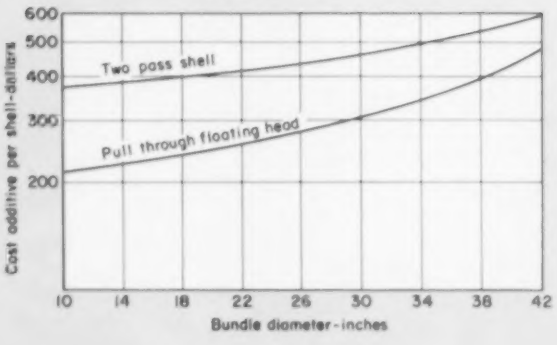


Fig. 76—Cost additives for pull-through floating head, and for two-pass shell

Courtesy of Western Supply Co.

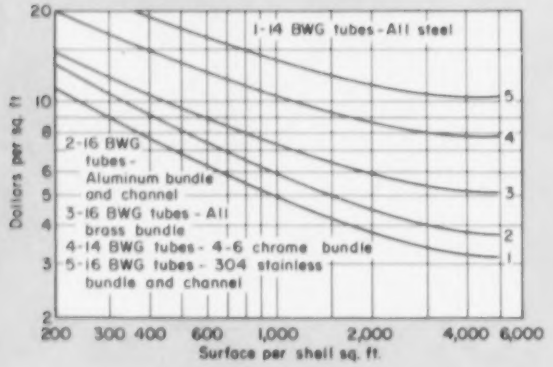


Fig. 77—Construction material varies cost of floating-head exchangers

Courtesy of Western Supply Co.

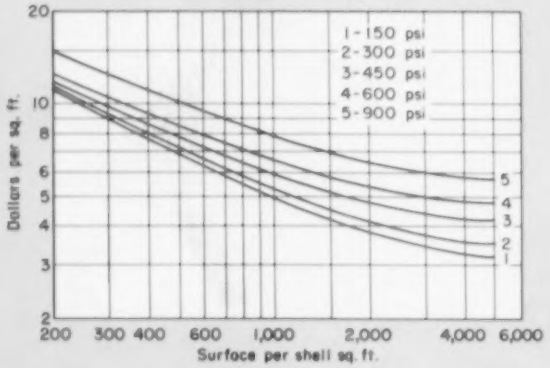


Fig. 78—Design pressure varies cost of floating-head exchangers

Courtesy of Western Supply Co.

COST OF STRAIGHT TUBE, KETTLE REBOILERS

Surface sq. ft.	Shell diameter, in.	Tube bundle diameter, in.	150 psig Price $	300 psig Price $
245	28	16	3,500	3,800
400	32	20	4,300	4,700
700	36	24	5,500	6,100
1,250	44	30	7,500	8,500
2,000	54	36	9,800	12,000
2,600	60	40	11,700	14,800

All steel. ASME & TEMA
3/4" O.D., 14BWG tubes 16'-0" long on 1" square pitch

Fig. 79—Prices for reboilers

Courtesy of Griscom-Russell Co.

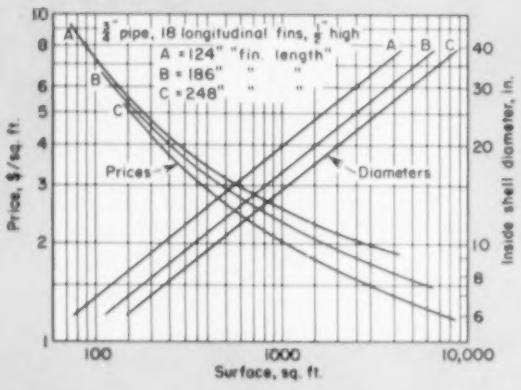


Fig. 80—Prices for fin-tube tank suction heaters

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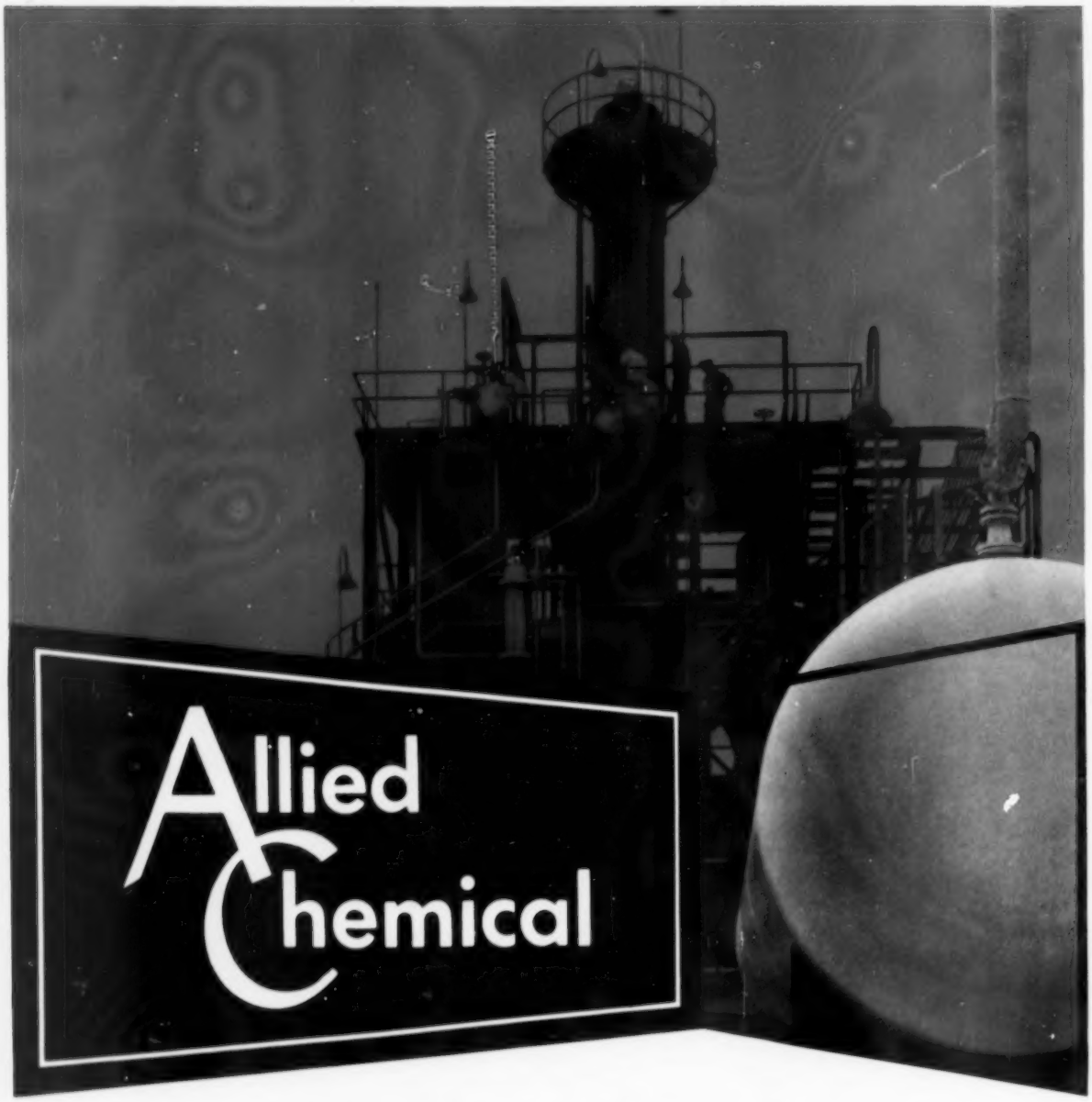

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INDEX TO ALL DEPARTMENTS

"Clip-n-File" Process Data 137
Plant Practices 141
New Words in Your Reading 147
"Clip-n-File" Engineering Data 149
Personals 153
Suppliers 159
Patents 163
Meetings for Oil Men 167
New Books 175
Operating Trends 177
Information Offered 180
Advertisers' Index 182
Readers' Service Card 183
What's New 185
Editorials 220

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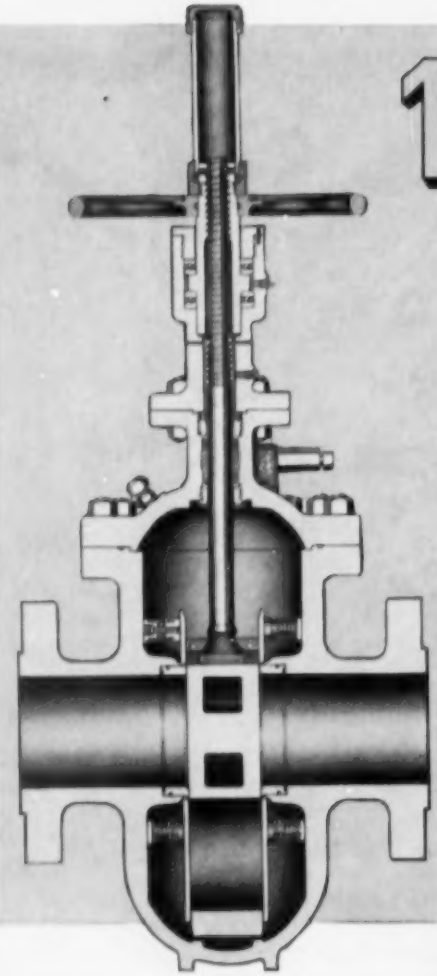

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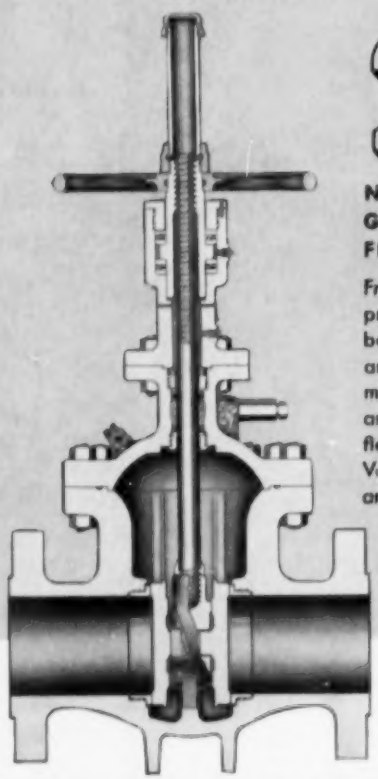

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Process Flow—Coking occurs in a thin liquid film on circulating, fluidized seed coke agitated by rising gaseous products and a small amount of steam fed into the bottom of the reactor.

The unit—shown in the flow diagram—consists basically of a reactor (or coking vessel) and a heater (or burning vessel). Fluidized coke circulates between reactor and heater. Heat for the coking reactions is supplied by burning some of the coke in the heater to heat the rest of the coke. Heated coke enters the reactor, vaporizes and cracks the feed, then flows down through a stripper and to a standpipe-riser system to return to the heater. Hydrocarbon vapors are removed from the coke by steam in the stripping zone.

Feed, injected into the hot fluidized coke bed, becomes heated. Vaporization and cracking occur, with products of dry coke (deposited on the circulating coke) and dry overhead vapor.

Reactor vapor products go to a cyclone separator in the top of the reactor where most of the entrained coke separates and returns to the fluid bed. Some coke dust stays in the cyclone outlet vapors, going to the scrubber tower bottom.

In the scrubber tower bottom, the heaviest part of the product condenses, then recycles to the reactor together with the collected coke particles in the form of a slurry. The upper portion of the tower is a conventional still designed for desired liquid product separation.

Coke (minus that burned in the heater) is withdrawn as product, and means are provided for controlling the size of particles circulating within the unit.

Operating Conditions—Operating pressures are substantially atmospheric, though higher pressures may be used. Reactor temperature is usually 900-1050°F. Coke burned in the heater is around 5 wt.% on feed. Pitch is fed to the reactor at 500-700°F, and the heater raises the fluid coke temperature to 1100-1200°F.

Feed Stock—Typical feed stock is vacuum residuum—however, pilot plant tests indicate that any feed that can be pumped may be used. Lighter components in coker feed have little or no effect on heavy component coking.

With long residuum as feed stock, lower coke, naphtha and gas result, but gas oil is much higher.

Table 1—Ultimate yields for Fluid Coking of vacuum residua

(Recycling fractionator bottoms to extinction)

Crude Source of Feed	So. Louisiana Mixture	Hawkins	Elk Basin
Feed Inspections			
Gravity, °API	13.2	4.2	2
Conradson Carbon, wt.%	14	24.5	30
Pour point, °F	120+	120+	120+
Sulfur, wt.%	0.9	4.3	3.8
Carbon, wt.%	87.3	85.1	86.4
Hydrogen, wt.%	11.5	10.1	9.8
Hydrogen/Carbon ratio	1.57	1.41	1.35
Ultimate Yields on Coker feed			
C_3 and lighter, wt.%	8	9.5	10
C_4/430°F V.T. naphtha, vol.%	24	23	22
Research octane, clear	77	77	77
Sulfur, wt.%	0.1	0.7	0.3
430/1015°F V.T. gas oil, vol.%	61	52	45
Gravity, °API	21	17	17
Sulfur, wt.%	0.6	3.7	2.8
Coke, wt.% (gross)	16	27.5	34

Table 2—Yields and product quality for Fluid Coking various feeds

Crude Source of Feed	Los Angeles Basin Residual		Panhandle	West Texas	Coleville	Ordonez
Feed to Fluid Coker	Virgin Pitch	Asphalt	Visbreaker Tar	Vacuum Pitch	Vacuum Pitch	Vacuum Pitch	Vacuum Pitch
Feed Inspections							
Gravity, °API	6.7	—0.2	—3.5	17.3	8.4	3.7	2.5
Conradson Carbon, wt.%	17	33	41	11	19	21	24
Sulfur, wt.%	2.0	2.3	2.1	0.7	3.5	4.2	4.4
% distilled @ 1000°F	25	0	5	——	——	——	——
Ultimate yields on Coker feed							
C_3 and lighter, wt.%	8	10	11.5	7	9	9.5	9.5
C_4, vol.%	2.5	3	3	2	3	3	3
C_4/430°F, naphtha, vol.%	16.5	17.5	14.5	21	21.5	20	20
430/1015°F gas oil, vol.%	61.5	44.5	32.5	68.5	58	54	49.5
Coke, wt.% (gross)	20.5	36	48.5	11.5	19.5	24	30
Product Quality							
Naphtha gravity, °API	——	——	——	59	56	54	56
Sulfur, wt.%	——	——	——	0.2	0.7	1.3	0.6
Research octane, clear	——	——	——	66	78	82	77
Gas oil (430/1015°F), °API	——	——	——	29	20	15	17
Sulfur, wt.%	——	——	——	0.4	2.6	3.8	3.7
Characterization Factor	——	——	——	11.98	11.27	11.04	11.10

Yields are close to a combination of vacuum distillation and coking of vacuum residuum.

Product Yields—Ultimate conversion is possible with recycle operation, eliminating heavy fuel oil production from a refinery.

Fluid Coker gas oil (430/1015°F V.T.) is the major product—may be 50-60% on residuum feed. Coker gas oil is lower quality than virgin gas oils, shown by gravities in Tables 1 and 2. As catalytic cracker feed, coker gas oil in general gives somewhat better yields than catalytic cycle stock. As compared with virgin gas oil, it gives somewhat lower conversion, and the carbon formed is about double that of virgin gas oil at the same conversion. About 30% of the 430/1015 cut could make 430/650 heating oil, but would need treating.

Fluid Coker naphtha is about 10 Research octane higher than delayed coker naphtha, but is still only about 77 R.O.N. for a C_5/430°F cut. It usually needs treating by clay, catalytic reforming, hydrogen finishing, etc., as it has high gum and low breakdown time. C_4/430 coker naphtha has about 13 vol.% C_4, about 75% unsaturated. This, with unsaturates from reactor gas, can make good polymerization plant feed.

Gross coke yields are about 1.1 times the Conradson carbon in the feed. Net coke make can be increased by using other fuels in the heater, instead of burning some of the coke. Sulfur from the feed concentrates in the coke, and most of the ash stays in the coke.

Coke physical properties differ from other petroleum cokes. It is being used by a public utility as fuel and other studies are being made on specialty product applications.

Gas from Fluid Coking changes little with feed quality. A typical analysis (minus H_2S) is:

Hydrogen	16 mol%
Methane	41 mol%
Ethylene	10 mol%
Ethane	16 mol%
Propylene	10 mol%
Propane	7 mol%

Typical yields and product qualities are given in Tables 1 and 2, where Hawkins and Elk Basin pitches are heavy feeds for Fluid Coking, and the Southern Louisiana mixture is light better quality feed.

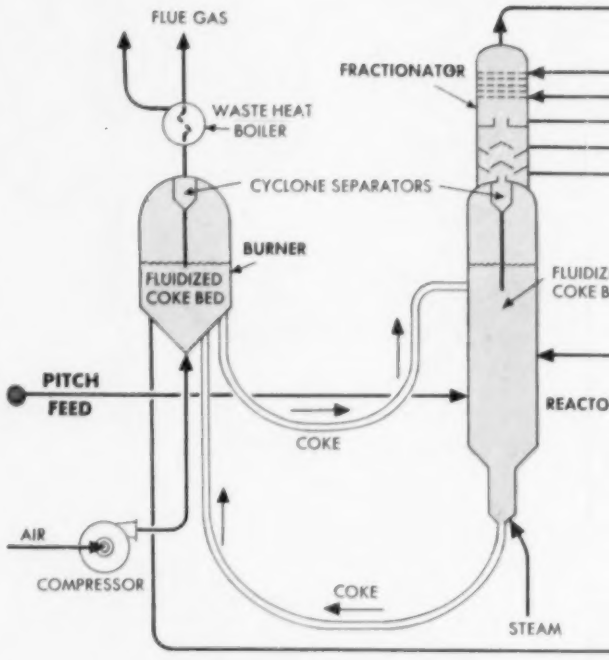


Table 3—Fluid Coking economics—10,000 b/sd Gulf Coast Plant

(with catalytic cracking of coker gas oil, and products treating)

Crude Source of Vacuum Pitch	So. Louisiana Mixture[1]	Hawkins
Yields on pitch (see Table 1)		
C_3 and lighter, wt.%	8	9.5
C_4/430 naphtha, vol.%	24	23
430/1015 gas oil, vol.%	61	52
Coke, wt.%	16	27.5
Product Values, $/bbl. pitch	2.63	2.12
C_3 and lighter @ $0.90/bbl., $[2]	0.07	0.09
C_4/430 naphtha @ $3.20/bbl., $	0.77[3]	0.74[3]
430/1015 gas oil:		
So. Lousiana @ $2.70/bbl., $	1.65	——
Hawkins @ $2.00/bbl., $	——	1.04[4]
Coke @ $5.00/ton, $	0.14	0.25
Feed Value, $/bbl.[5]	1.25	0.75
Value added by coking, $/bbl.	1.38	1.37
Coker operating cost, $/bbl. pitch[6]	0.24	0.24
Gross profit, $/bbl. pitch	1.14	1.13
Coker Investment (battery limits), $ per b/cd	235	250
Return before taxes, %/year on invest.[7]	175	165
Return after 55% income taxes[7]	80	75

(1) Product desulfurization not necessary
(2) Feed equivalent
(3) Allowance made for clay treating
(4) Allowance for hydrofining coker and catalytic naphthas
(5) Allowance for hydrofining gas oil
(6) Evaluated as components in No. 6 fuel oil
(7) Excluding royalty

Table 4—Typical operating requirements

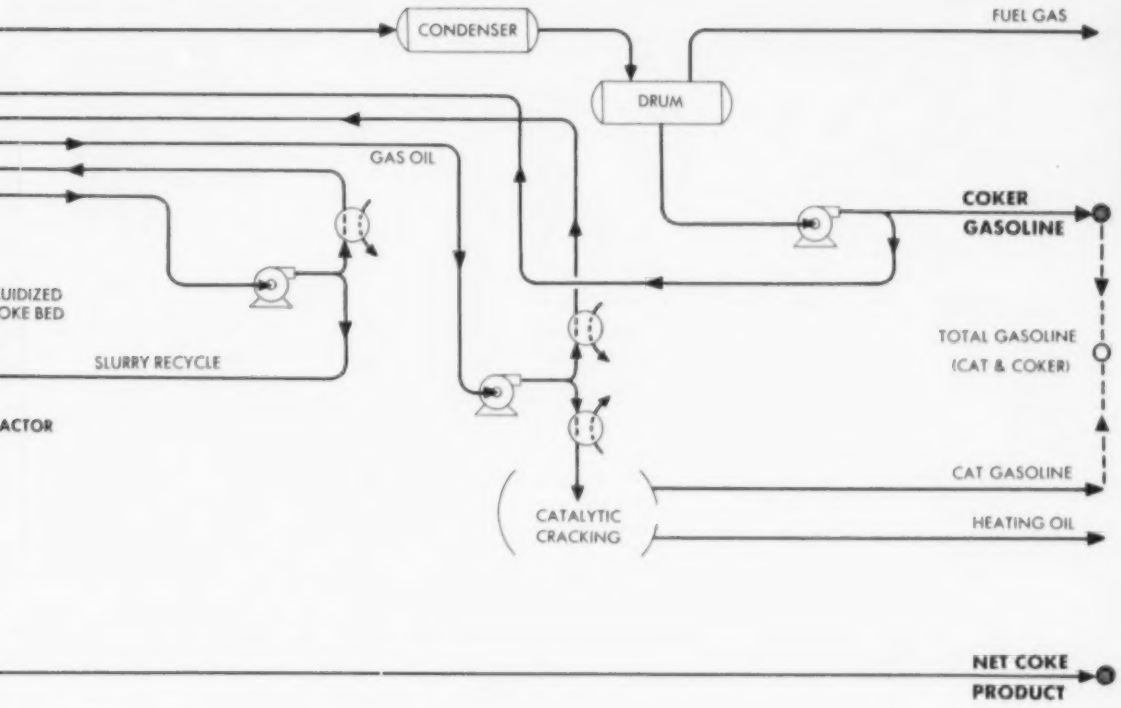
(10,000 b/sd plant, Fluid Coking)

Investment	$2,300,000
Operators/shift	3
Utilities	
Fuel	110 MM Btu/hr.[1]
Steam	21,000 lb./hr.[2]
Cooling water	6,000 gpm
Power	1,500 kw

(1) Normally coke burned in process.
(2) Assume no waste heat boiler. About 14,000 lb/hr. steam could be generated in waste heat boiler on the flue gas from the burner.

Economics—Fluid Coking residual oils to lighter products usually increases pitch value $1.25-2.00/bbl. on a Gulf Coast basis (with heavy residuum for blending into fuel oil at $0.75-1.25/bbl.).

Table 3 gives economics for typical Gulf Coast conditions with fuel at $1.75/bbl. and 93 Research octane gasoline at 12¼¢/gal. Coker product values assume catalytic cracking of coker gas oil. Deductions were made for light ends recovery, catalytic cracking and products treating for oper-



Coke and Lighter Products

From Low-Grade Oils by Fluid Coking

UNFOLD FOR START OF PROCESS DESCRIPTION

ating cost and 10% return on investment after income taxes (including general facilities). Hydrogen for treating is assumed from an existing catalytic reformer.

Fluid Coker investment is based on hot feed injection and includes reactor and heater sections, overhead scrubber-fractionator and equipment for coke withdrawing and seed coke feeding.

Operating costs include depreciation, payroll burden and general refinery overhead, and are based on Table 4 operating requirements.

Installations—Fluid Coking units in operation are: Carter Oil Co., Billings, Mont., 3,800 b/d and Esso Standard Oil Co., Baltimore, Md., 10,000 b/d. Units under construction are: Tide Water Associated Oil Co., 42,000 b/d units at Avon, Calif. and Delaware City, Del.; Aurora Gasoline Co., Detroit, Mich., 4,000 b/d; Canadian Petrofina Ltd., Montreal, Canada, 4,000 b/d. Under design are: Pontiac Eastern Corp., Hattiesburg, Miss. and Bankline Oil Co., Bakersfield, Calif., 4,000 b/d each.

Licensor—Esso Research and Engineering Co., 15 W. 51st St., New York 19, N. Y.

References—Selected literature items giving more information on Fluid Coking are:

(1) Anon., "Fluid Coke Can Compete for Fuel and Metallurgical Coke Markets," PETROLEUM PROCESSING, Nov., 1954, pg. 1664.
(2) Anon., "New Fluid Coking Process," PETROLEUM PROCESSING, Sept. 1953, pp. 1316-7.
(3) Barr, F. T. and C. E. Jahnig, "Fluid Coking and Fluid Coke," American Institute of Chemical Engineers, New York Section, Oct. 1954.
(4) Johnson, F. B. and R. E. Wood, "Fluid Coking—Yield Studies," Western Petroleum Refiners Assn., Sept. 1954, Casper, Wyo.
(5) Martin, H. Z., F. T. Barr and R. W. Krebs, "The Fluid Coking Process," Western Petroleum Refiners Assn., Mar. 1954, San Antonio, Tex.
(6) Thornton, D. P., Jr., "Why Carter Likes Its Coker," PETROLEUM PROCESSING, June 1955, pp. 840-5.
(7) Voorhies, A., Jr., and H. Z. Martin, "Fluid Coking of Residua," American Petroleum Institute, Nov. 1953, Chicago, Ill.—reviewed in PETROLEUM PROCESSING, Dec. 1953, pp. 1880-1.
(8) Voorhies, A., Jr., "The Fluid Coking Process: From Pilot Plant to Large-Scale Application," California Natural Gas Assn., April 1955, Los Angeles, Calif.

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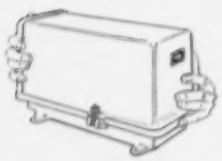

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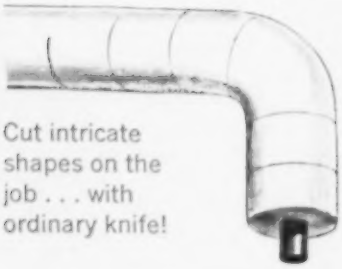

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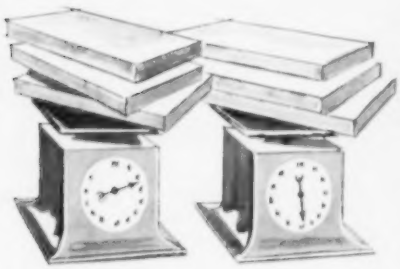

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(To obtain more data on advertised products see page 182)

THIS SIMPLE HOIST is a big help in . . .

LIFTING deep well pump

Air-Power Puller Saves Time on High Lifts

ONE of the most tiresome and time-consuming jobs in plant maintenance is lifting such items as deep well pumps and exchanger bundles to high places. Unfortunately it is not always possible or practical to use electric hoists, especially on equipment structures.

A simple system developed by the mechanical department personnel at Socony Mobil Oil Co.'s refinery in East St. Louis, Ill., has reduced the lifting time in such jobs by 90%. Except for one item, every piece of equipment used was salvaged from the scrap-pile. And the hoist crew has been cut to one man, who expends very little effort.

The usual procedure in pulling a 15-ft. multistage pump, or lifting an exchanger bundle from the ground to or within the structure, has been to put one or two men on the falls of a chain hoist and "strong-arm" the load. Since the gear ratio is rather high it may take 45 minutes to pull a pump, or 90 minutes to lift a bundle 25 ft. The pull which the men exerted may reach 200 lbs, with early exhaustion setting in.

The manpower-saver that was devised is a removable "power-pulley," made from an old hoist wheel. This was mounted on a shaft in sleeve-bearings and machined at one end to take an adapter for a conventional air-motor. The bearing supports are bolted over the bearings to permit easy removal of the wheel and shaft without special tools.

Mounted in a box made of channel iron and steel plate are the bearing supports. The power pulley is mounted near one end, leaving space in the other end to hold sand or iron, which acts as a weight. This prevents the puller from "creeping" or "climbing" the chain when a load is handled.

When positioned for a job the chain fall of the hoist is passed over the wheel on the power puller and the box is shifted until the chain is moderately tight. Bolting the bearings to the supports allows passing the chain over the wheel. Another arrangement would be to secure the wheel with a pin or bolt, slipping the shaft out.

To move the load requires only connecting the air motor to the wheel shaft, and turning on the air. Turning the box around permits lowering a load. This arrangement does not interfere with normal use of the hoist for other work, such as positioning slings and moving the load by increments for proper positioning. Its portability means it can be used almost anywhere.

As pictured above, the lifting of a 15-ft. multistage pump now requires only 4 minutes. Lifting a tube bundle 25-ft. can be done in 10 minutes now with this power puller.

Steam Cuts Pump Seal Leakage

LOW pressure steam has been found effective in reducing leakage of mechanical seals on pumps in wet propane service at the Shell Oil Co. refinery, Wood River, Illinois.

Slight propane leaks often cause ice crystals to form on the sealing faces of the mechanical seals. This forces the faces to part and permits excessive leakage.

Exhaust steam at 15 psig is injected into the cooling water chamber of the mechanical seal glands, or applied externally. The melting of the ice crystals allows the seal to again re-establish itself. Vaporization in the stuffing box is prevented by localizing the steam injection to the glands. The injections have been either continuous or intermittent, with no adverse effects observed.

(More 'Plant Practices' on pg. 142)

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Pipe Support Jig Aids Welding

ONE of the time-consuming jobs around the refinery pipe-shop is lining up various sections and subassemblies of a piping system so that the entire assembly is accessible to the welder without risk of disturbing the arrangement, at least until tack-welding is completed. Sometimes the components are laid out on the floor, or supported in various ways, sometimes makeshift, until tacked. Then the assembly is moved to a more convenient working position for making the finished welds.

Cosden Petroleum Corp.'s refinery pipe-shop at Big Spring, Texas, uses adjustable home-made pipe support jigs which expedite set-up time. They accommodate most sizes of pipe and fittings. When the components are properly oriented there is no need to move the work until it is completed.

The three-legged jigs are fabricated from scrap pipe, nipples, plate, nuts and bolts, and similar oddments to be found in every refinery scrap-pile. The two jigs shown above consist of a short length (2 ft.) of 2-in. pipe with three steel plate legs and feet welded to one end. The other end of the pipe is drilled about 2-in. from the end, and a ¼ or ⅜-in. nut is welded flush with the hole. An old valve handle attached to a short length of threaded stud is screwed into this; it holds the telescoping section at any desired position.

The telescoping section is a 30 in. length of 1½-in. pipe. On this pipe is mounted an 8-in. length of 1-in. stud, threaded rod or all-thread nipple. This carries a spider made from a 1-in. nut to which three or four lengths of half-inch rod have been welded. A V-shaped piece of steel plate is welded or screwed to the threaded rod, and forms the pipe support. If desired, the rod is not completely threaded; an inch or so at one end can be left as a safety stop.

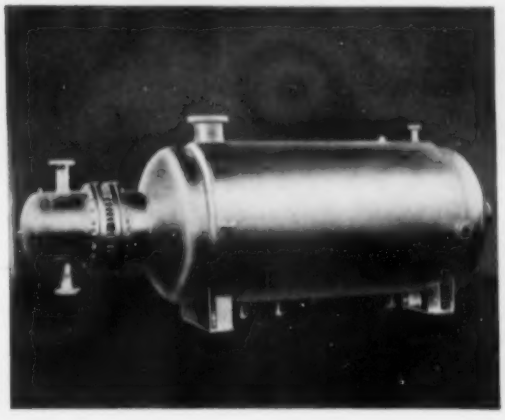
These stands are adjustable from about 3 ft. to 5 ft. above the floor, with an additional 6-in. of fine adjustment via the threaded section. Shorter or taller stands can be made by varying the dimensions above.

ECONOMY
High-alloy layer—usually 10% or 20% of total plate thickness—assures corrosion and abrasion resistance, long equipment life.

DESIGN FREEDOM
Integral bond allows design and fabrication of shapes to meet process and space needs.

STRUCTURAL STABILITY
Low-cost carbon steel backing provides necessary strength and rigidity.

Nickel-clad steel gives this jacketed heating unit high corrosion resistance in processing light hydrocarbons and dilute hydrochloric acid.



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ECONOMICAL SERVICING. Instead of removing trap from a pipe-line, you can open and service a Super-Silvertop in the line, since all connections are in the head.

SUPERIOR DESIGN. Super-Silvertops have simplified piping without thin-walled passages. Other traps have built-in piping which results in narrow, hard-to-clean passages that cause gaskets to blow.

ANDERLOY VALVE AND SEATS. Developed by Anderson to combat the erosive effect of steam. Eliminates replacement of valve and seat assemblies.

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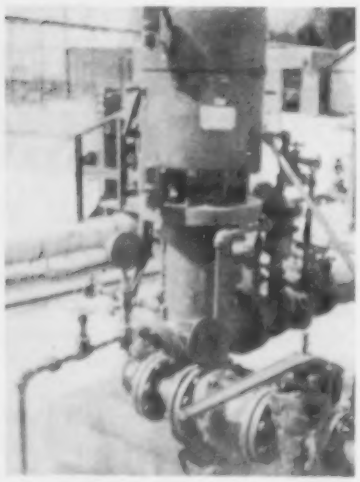
How to Patch Pipe In an Emergency

A RAPID method for repairing pipe line in refinery emergencies is suggested in Civil Defense Technical Bulletin, TB-13-11—available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

The materials are relatively simple to use, and special skills or tools are not needed. The patching material is composed of a resin and liquid activator, used either as plugging putty or as a sealer over glass fiber cloth. It will adhere to nearly any surface, has high tensile and compressive strength and is shock resistant. The material is self-curing even when in contact with water, oil, gasoline and other liquids. Curing time is about 30 minutes.

The repair compound is effective for use with water, gas, low-pressure steam, gasoline, alcohols and other liquid lines under normal pressures up to 300 psi.



Upside-Down Trap Prevents Vapor Lock

WHEN using vertical pumps in butane service, it is necessary to prevent vapor from entering the intake line and causing the pump to stick. An upside-down ball float trap is used at Shell Oil Co.'s Wood River, Ill., refinery to insure satisfactory butane pump operation.

Instead of the ball float opening as the liquid rises, the ball float closes as the liquid level rises. As a result, when the liquid level drops, the valve opens and allows the vapor to escape before it reaches the suction of the butane pump.

Here's Stainless Steel used for SO_2 drying

Continental Oil Refinery No. 3, Lake Charles, Louisiana

This primary drying tower operates at 200° F., and it is used to dry sulfur dioxide. As every engineer knows, it only takes a little bit of water to turn the sulfur dioxide into sulfurous acid. Because of this, the tower is made of solid Type 316 Stainless Steel. The reboiler is a solid Type 316 with Type 317 tubes.

Every refinery is a showplace for Stainless Steel, because no other metal combines so many desirable properties. When *designing* with Stainless Steel, remember that United States Steel can furnish a greater variety of grades, types, sizes and finishes of Stainless Steel.

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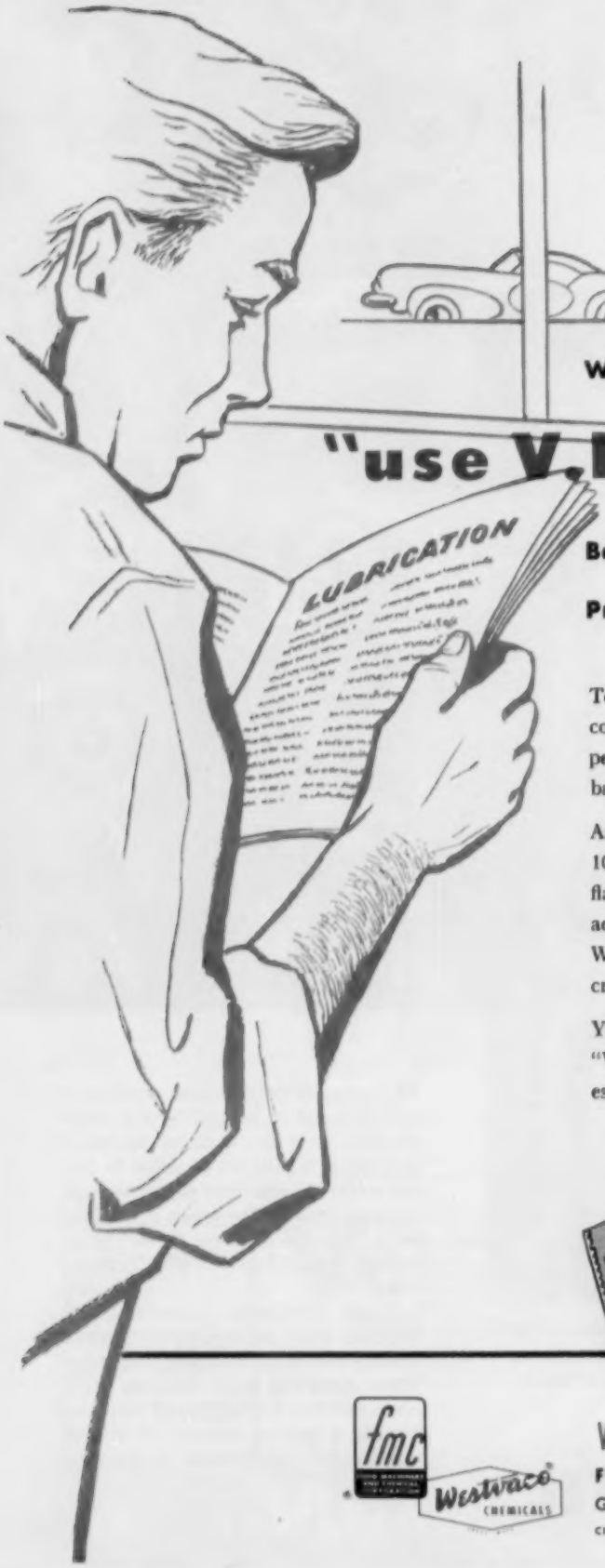

When The Owner's Manual Says

"use V.H.D. oil only"

Barium-based Additives Will Still Provide an Extra Measure of Protection

Today, 75% of detergent additives are barium based. As compression ratios go up, chances are that an even greater percentage of tomorrow's V.H.D. oils will contain barium-based additives.

Anticipating the trend, we recently increased capacity 100% . . . and stand ready to increase again. We pioneered flake Barium Octahydrate and Barium Pentahydrate . . . advanced forms of soluble barium values now widely used. We also have acquired another large mineral deposit to increase further ore reserves. These efforts continue.

Yes, you can be sure when the owner's manual specifies "V.H.D. Oils Only", we still expect to be America's largest producer of barium alkalis for oil additives.

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Do You Know These Words?

By B. H. WEIL
Manager, Information Services
Ethyl Corp. Res. & Engrg. Dept.
Detroit, Mich.

A regular department intended to help administrators and operating men alike keep abreast of technical names and processes in the petrochemical field.

Isoprene

Isoprene, pronounced **"eye**-so-preen," is a petrochemical that today faces quite an intriguing future—possible use in the commercial synthesis of "synthetic tree rubber."

Long known as Dame Nature's monomer or building block for natural rubber, isoprene—which has the formula $CH_2{=}CH{-}C(CH_3){=}CH_2$ — until recently defied man's repeated attempts to produce a good synthetic rubber from it. It was the failure of previous work on isoprene which drove industry to the use of its cousin, butadiene ($CH_2{=}CH{-}CH{=}CH_2$), which even now requires copolymerization with styrene to yield a useful synthetic, GR-S. During the past year, however, several rubber companies have each announced the successful preparation of a suitable polyisoprene synthetic rubber, and commercialization may be just around the corner.

Isoprene itself is a colorless, volatile liquid which boils at summer temperatures (97°F.) and freezes far below the freezing point of water. Prior to World War II it was obtained (in small quantities) from turpentine and even from the cracking of natural rubber. During World War II and since, however, it has found commercial use in the synthesis of Butyl synthetic rubber—prime material for innertubes and tubeless-tire innerliners. Being a highly reactive chemical, it is expected to find other uses in synthetic organic chemistry; for example, it reacts with such materials as maleic anhydride to form cyclic anhydrides.

Isoprene is currently manufactured from petroleum by the cracking of distillates in the presence of steam. The resulting mixture of unsaturated materials is then subjected to an extraction process for removal of the isoprene.

The commercial production of polyisoprene "synthetic tree rubbers" would fill an important gap in the present domestic-production picture by providing a material which could be used in truck and other heavy-duty tires, where GR-S rubbers are not completely satisfactory. Producers of pilot quantities sound highly optimistic, so the raw material for this new-old elastomer—isoprene—may well come into sudden, heavy demand.

Ammonium Sulfate

Ammonium sulfate, pronounced "ah-**moe**-nih-ahm **suhl**-fate," has long been one of the most widely used nitrogenous fertilizers, and continues to find large-scale use in this field despite the competition of newer nitrogenous materials. A brownish-gray to white solid, depending upon its purity, this chemical is slightly heavier per unit volume than sugar, and is soluble in water.

Traditionally, ammonium sulfate is a byproduct of the coking of coal, the ammoniacal vapors from this operation being passed through sulfuric acid, and the resulting ammonium sulfate then being crystallized and dried. During the past decade or so, however, increasingly large quantities have been produced at synthetic ammonia plants, again by direct reaction with sulfuric acid. It is this latter method which gives us the right to classify ammonium sulfate as a petro-chemical, since synthetic ammonia, as pointed out earlier in this series (PETROLEUM PROCESSING, Feb., 1954, pg. 242), is produced from hydrogen obtained from natural gas, as a byproduct from the catalytic reforming of petroleum naphthas, etc.

Ammonium sulfate has commercial applications other than in fertilizers—synthesis of ammonium hydroxide, charging of electric batteries, use in fireproofing compositions and soldering liquids, galvanizing of iron, etc. None of these, however, approaches anywhere near the volume of use in fertilizers.

The future of synthetic ammonium sulfate seems somewhat anomalous. The high rate of steel production has meant larger supplies of byproduct ammonium sulfate. In the last five years, exports have exceeded imports only in 1955. Cheaper fertilizers (ammonium nitrate and anhydrous ammonia) offer a continued threat, as does more-versatile diammonium phosphate. But certain producers of synthetic ammonia continue to install new ammonium sulfate facilities, so this veteran fertilizer material is apparently still a money-maker.

NEWS in VIEWS

CANADIAN OIL INDUSTRY'S FIRST mass spectrometer is now in operation at British American's Montreal refinery. The $60,000, 20 chassis unit is expected to aid substantially in boosting product quality and process efficiency. For more details on Montreal refining operations see story starting on pg. 72

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the cellular, stay-dry insulation

STAYS DRY—Cut a piece from your sample. Place it in water. Note how the hermetically-sealed glass cells filled with dead air keep it afloat. Weight it down for days, weeks or longer if you like. Remove the weight and it bobs back to the surface . . . proof that the sealed cells have absorbed no water, still have their original insulating efficiency.

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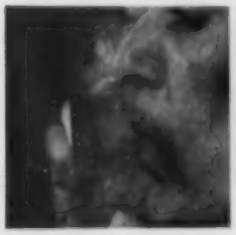

VAPOR-PROOF—With a nail file, cut a ¼" thick slice from your sample. Hold it to your lips and try to blow smoke through it. The smoke won't penetrate . . . proof that FOAMGLAS is a positive vapor barrier in itself.

STRONG AND RIGID—Place your FOAMGLAS block on the floor. Stand on it. Note how it supports your weight without crushing. Compressive strength is over seven tons per square foot . . . making it ideal for load bearing applications.

INORGANIC AND FIREPROOF—Hold a flame to your sample. You'll see at once that it does not burn . . . a major safety feature in all construction. It's even acid-proof and rodent-proof as you can prove if you happen to have a vial of acid or a pet rat handy.

LIGHT WEIGHT—Just pick up your sample to see how light and easy to handle it is. Check actual weight on your company's postal scale if you wish. The density of FOAMGLAS is only 9 pounds per cubic foot.

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Fluid Flow—Fundamentals

DEFINITIONS: Gases as well as liquids fall under the name of fluids. Their common characteristic is the ability to flow or change shape under the slightest pressure. No fluid regains its original shape once the pressure is removed, as do elastic materials. Technically there are two types of fluids: Newtonian, which includes most liquids and gases; and non-Newtonian, which flow only after a certain initial pressure has been applied—as with plastics.

HOW IT IS MEASURED: The most common method of moving fluids is by pumping (or otherwise forcing them) through a pipe. Although in theory this method involves many factors, the most practical one is "How much pressure is required?"

In refining processes the pressure of fluids is important since they are often pumped into vessels held at closely controlled operating pressures. Also the pressure (energy) needed to overcome the friction encountered in long pipe systems will determine the pump size and cost.

The sketch below shows how the pressure drop encountered in pumping fluids through a piping system is calculated, as well as the main factors involved.

As can be seen in the above Fanning's formula, pressure drop in a pipe (due to friction only) varies:

Directly with the pipe length, L

Directly with the density of the fluid, ρ

Directly with the friction factor for the pipe, f

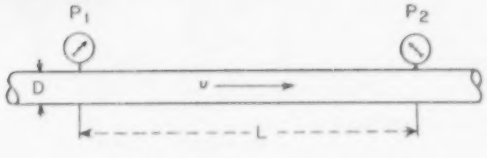
Inversely as the pipe diameter, D, and

As the square of the flow rate, v.

This simple relationship does not take into account the pressure loss due to pipe fittings. The coefficient of friction, f, is a function of both the roughness of the pipe's inner wall and the physical characteristics of the fluid—its viscosity and density.

HOW PRESSURE DROP IS MEASURED

PRESSURE DROP IN PIPE



$$P_1 - P_2 = \frac{f L \rho v^2}{2gD}$$

f = coefficient of friction

ρ = density of fluid

g = acceleration of gravity

TYPES OF FLOW: Within a pipe fluids may flow in orderly fashion, descriptively called **laminar** or streamline flow. But for every set of flow conditions there is a point of which this orderly flow ceases and **turbulent** flow exists. Between these two is the critical region, in which the flow alternates between laminar and turbulent.

These various types of flow were first discovered by Osborne Reynolds in 1883, and it is after him that a special term associated with fluid flow is named—the Reynolds number. Use of the Reynolds number permits us to predict whether a flow will be laminar or turbulent, as well as the magnitude of the coefficient of friction. On the back of this sheet is a graph showing this relationship.

THE REYNOLDS NUMBER: The nature of flow in pipes depends on four factors: (1) pipe diameter, D; (2) fluid density, ρ; (3) fluid viscosity, μ; and (4) velocity of flow, v. The Reynolds number is a dimensionless relationship between all these factors; it indicates whether the combination will result in turbulent or laminar flow, as well as the magnitude of the coefficient of friction. The relationship is stated

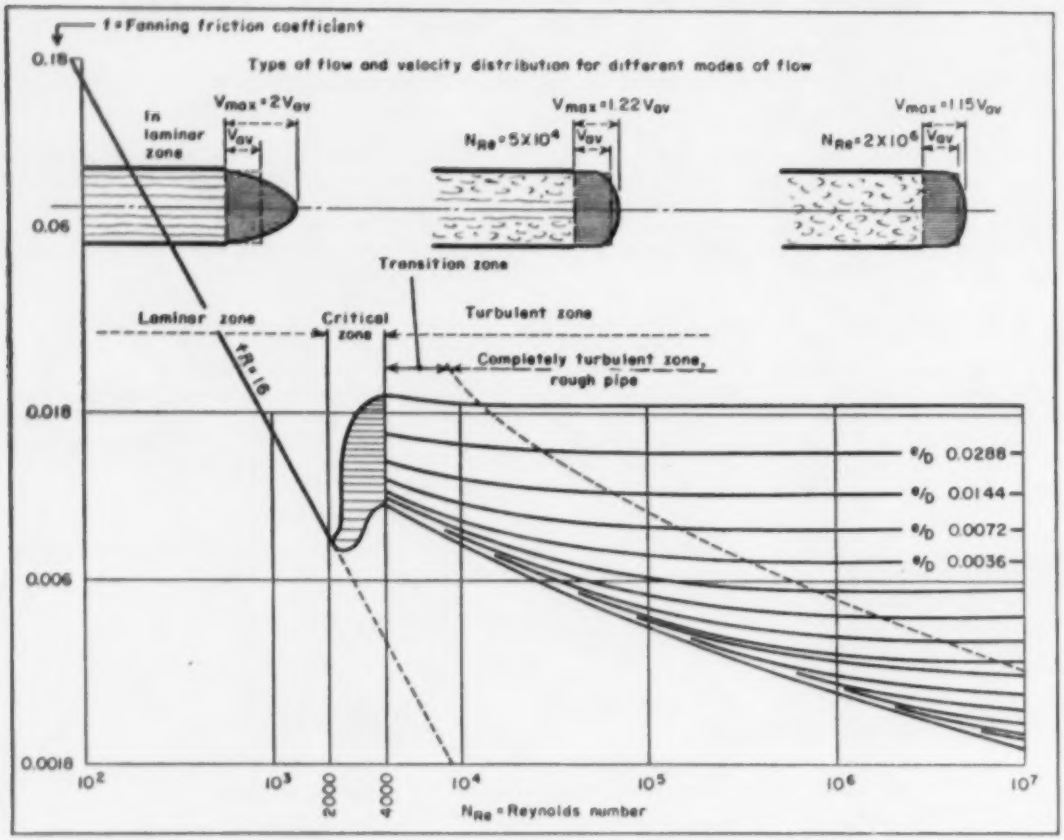
$$N_{Re} = D v \rho / \mu.$$

Pressure loss in a pipe is a measure of the energy needed to overcome resistance to flow, due either to friction between the fluid and the surface of the pipe or to the internal resistance of the fluid itself. In laminar flow the resistance to flow depends only on the viscosity of the fluid and is unaffected by the roughness of the pipe wall. For this region the relationship is simple $f = 16/N_{Re}$.

However for turbulent flow, especially in the higher range of Reynolds number, the eddy-producing effects of rough pipe largely determine the resistance to flow. In this case the coefficient of friction depends on the relative roughness of the pipe wall, which is expressed as the ratio of the effective heights, e, of surface irregularities to the diameter, D, of the pipe. Values for different types of pipes are listed on the back of this sheet.

For More Data, Turn the Page . . .

● Coefficient of Friction—Reynolds number



From Tube Turns, Inc., Piping Engineering Booklet 3.01

SURFACE ROUGHNESS: It has long been known that pressure drop is affected by the kind of pipe used, specifically by its diameter and by the shape and size of the inner surface irregularities. Although it is not yet possible to express this effect mathematically, experimental data shows that the friction is proportional to a ratio of the effective heights, e, of the surface irregularities to the pipe diameter, D. This ratio is called the relative surface roughness. By itself or in conjunction with the Reynolds number it establishes the magnitude of the friction coefficient.

The table below lists the effective heights of different types of pipe.

Type of Surface		e(ft.)	
Drawn tubing (very smooth surfaces of all kinds)		0.000005	
Commercial steel or wrought iron		0.00015	
Asphalted cast iron		0.0004	
Galvanized iron		0.0005	
Uncoated cast iron		0.00085	
Wood stave	dependent upon smoothness of surface	0.0006	to 0.003
Concrete		0.001	to 0.01
Riveted steel		0.003	to 0.03

The ratio of the effective height to the pipe diameter D (using consistent units) provides a dimensionless quantity which establishes the magnitude of the friction coefficient.

SELECTING PIPE SIZE: In the construction and design of any pipe system the size of pipe selected is important, from both a cost and process design consideration. The size of the pipe will determine the velocity, which in turn affects the resistance to flow and the resulting power consumption of the pump. Too great a flow may also require costly high-strength pipe to safeguard against possible pressure surges, or it may produce unwanted erosion or cavitation.

As a rough guide, in the absence of more directly applicable information, one manufacturer recommends the following easily remembered rules. The alternate rules are not dimensionally consistent, but have been chosen for their simplicity. The velocity limits suggested are not absolute, but are included merely as a guide.

Fluid	Economic size	Reasonable velocity	Limiting velocity
Liquids	$d = 0.3Q^{\frac{1}{2}}$	$V = (d/2) + 4$	$V = 15$
Steam or gas	$d = 0.5v^{\frac{1}{2}}w^{\frac{1}{2}}$	$V' = d$	$V' = 15$

d = pipe diameter, in. Q = flow rate, gpm
V = velocity, ft./sec. w = flow rate, lb./hr.
V' = velocity, 1000 ft./min. v = specific volume, cu.ft./lb.

alkylation

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The persistent trend to higher compression ratios in automotive engines is focusing attention on alkylation as an important process means for increasing a refinery's Octane potential.

Foster Wheeler is currently designing and constructing an alkylation unit for a midwestern refiner which will produce 3800 bbl/day of motor alkylate. This unit features "effluent refrigeration," the most significant advance in alkylation technology in 15 years.

The unit shown in the photograph, recently completed for a South American refiner, is but one of the 17 alkylation units designed and constructed by Foster Wheeler. This cumulative experience is available to refiners everywhere — for evaluating the economics of the process and undertaking full responsibility for plant design and construction. For complete information, write to *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

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(To obtain more data on advertised products see page 182)

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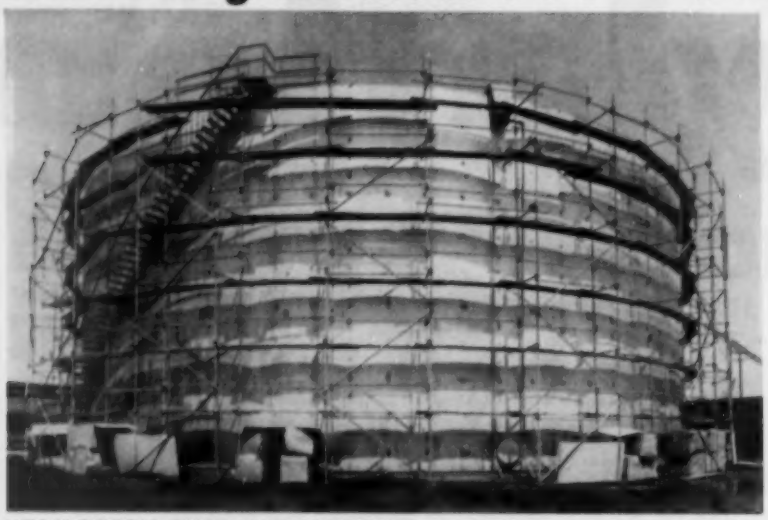
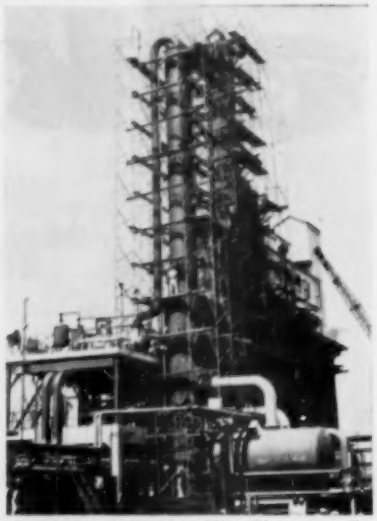
Scaffolding Methods . . . by Patent Scaffolding Co.

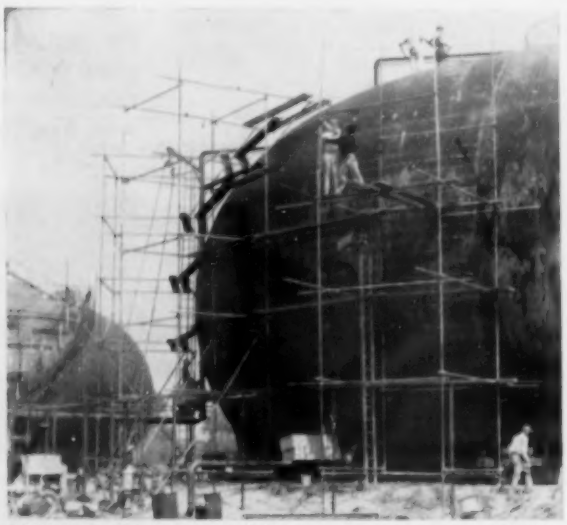


"TAILORED" TUBE AND COUPLER—Scaffolding curved or irregular shapes at multi-levels (such as on this Richfield Oil Co. storage tank at Harbor Island, Seattle) to extreme heights or on uneven terrain is fast and easy with "TubeLox"® Scaffolding. This all-purpose equipment for construction and maintenance uses only four basic parts. Interlocking 2″ or 2½″ o.d. steel tubes, 6, 8, 10, 13, 16 and 20-ft. long are joined by standard or adjustable steel couplers. "TubeLox" can be "tailored" to practically any conditions and gives workers access to all surfaces. Strong and fireproof, "TubeLox" is both versatile and economical for all petroleum industry jobs. Write for application details in Bulletin PTS-18.



TOWER WORK—The Koppers Co. uses "Trouble-Saver"® Scaffolding prefab sectional steel frames, 6′6″ high, to quickly erect scaffolding for maintenance work on stacks at Port Acres, Texas refinery. These fireproof units require no tools, go up faster than wood scaffolds. "Trouble-Saver" end frames are 5-ft. wide and vary in height from 3-ft. to 10-ft., 1-in. Write for Bulletin PSS-34.

HANGING HELPER—For decorating, painting and similar light-duty maintenance jobs, the "Gold Medal"® Midget Safety Swinging Scaffold offers time-saving at low cost. It is suspended quickly from "S" or "L" hooks on ¼″ steel wire cable; raised and lowered by light, compact Midget Machine. Write for Bulletin J-9(M).



SHAPED TO FIT—Insulation work on tanks at Gulf Refining Co., Toledo, Ohio, is done from cantilevered "Tube-Lox" tube-and-coupler Scaffolding which conforms easily to curved or irregular surfaces and odd shapes. Ideal for scaffolding on storage tanks, blowdown or alkylation plant stacks, vacuum units and exchangers.

To help you with your scaffolding methods, PS offers a complete nation-wide engineering service available to you locally. See the Yellow Pages in your 'phone directory for the nearest Patent Scaffolding office or representative that **sells** and **rents** "Gold Medal" Scaffolds.

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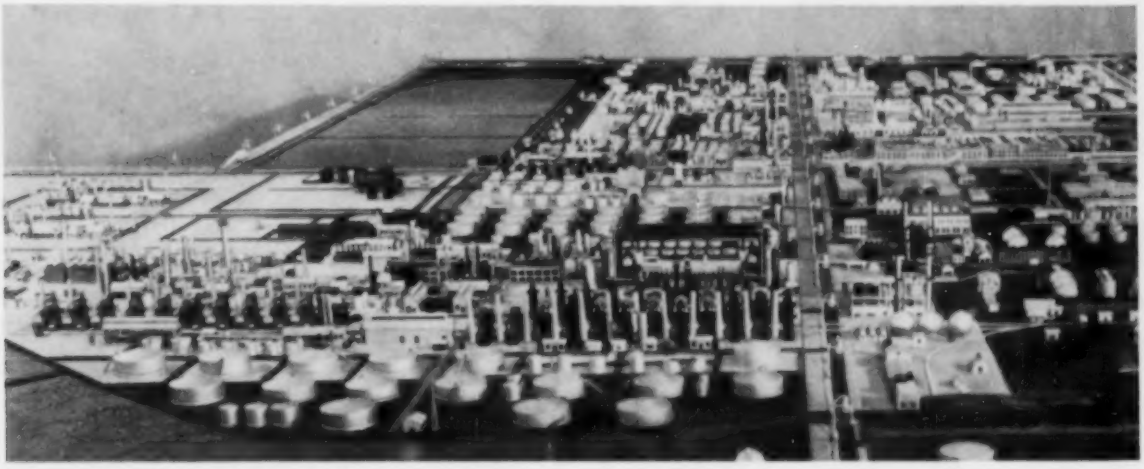

SEVEN-MONTH TASK of George C. Fairbairn, Texaco's Port Arthur refinery in a scale of one inch to 50 ft. Photograph omits part of tank field.

Texacoan's Model 'Shows the Public'

GEORGE C. Fairbairn's craftsmanship was turned to account for the oil industry in general and The Texas Co. in particular when his scale model of the Port Arthur refinery was shown during Oil Progress Week in downtown Port Arthur. It is complete even to the street lights, which spread a miniature glow over the exhibit when the room is darkened. The company asked him to build it during moments he could spare from the work of the product control division, where he was foreman. When its four sections are put together, the model measures 8x16 ft., with a 2-ft. projection on each side.

About the time it was brought to New York for further display, George Fairbairn left Texaco for retirement after 35 years' service. While he continues his handiwork in his home workshop, his "swan song" miniature will go on to show a larger public the immense scale of the modern petroleum refinery.

Conger Reynolds has retired as director of public relations for Standard Oil Co. (Ind.) after 26 years in that post. He has become chief of the office of private cooperation, U. S. Information Agency. He will direct the office's efforts to encourage nongovernmental American groups in activities that further international understanding and goodwill.

Reynolds was a newspaperman and member of the U. S. Foreign Service before taking the post with Indiana Standard in 1929. He has been succeeded by **Don Campbell,** who was assistant director.

In the company's research department, **R. J. Hengstebeck** has been appointed research associate in the process division, with responsibility for evaluation of new processes. He has been succeeded as group leader in the organic research division by **Dr. H. G. Krane.**

Dr. Philip Hill has been named patent advisor. His successor as group leader in the organic research division is **Dr. P. N. Rylander.**

E. P. Easterday has been appointed assistant to the administrative director of the research department in the Chicago office.

K. J. Kitzmiller has been appointed manager of the newly established aromatics department at the Shell Oil Co. refinery in Houston. He has been succeeded as manager of the gas department at the refinery by **M. L. Renquist,** who was assistant manager of the lubricating oils department.

Warren Thompson, assistant director, research and development department, of Sunray Oil Co., has been named manager of the research and technical service division.

L. D. Stewart, assistant general refinery superintendent of manufacturing for the West Tulsa plant, has been made assistant manager of the research and technical service division.

J. A. Middleton, assistant general refinery superintendent, mechanical, at West Tulsa, will manage the engineering, construction and maintenance division.

Gayle Rodgers has been appointed administrative assistant to the vice-president in charge of operations.

P. N. Johnson has been named president of the Salt Lake Refining Co. and the Salt Lake Pipe Line Co., both subsidiaries of Standard Oil Co. of California. Johnson succeeds **J. T. Higgins,** who has been advanced to general manager-operations of Socal's manufacturing department.

Johnson has been with Standard since 1939 and his experience includes work with the producing and engineering departments, as well as manufac-

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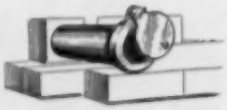
Ignition Port with Refractory Tile No. M896 . . . for use with standard 3" pipe. Also serves as a peephole.



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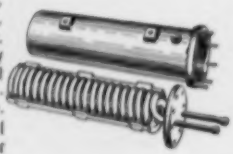

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turing. His last line assignment was as superintendent of Standard's El Segundo refinery.

John E. Wood has been named general manager of Esso Standard Oil Co.'s chemical products department. He was formerly assistant general manager of the department. He succeeds **O. V. Tracy,** who continues as an Esso director and president of the Enjay Co., an Esso subsidiary. Tracy directs all of the company's chemical products operations.

Wood joined the company in 1939 at the Esso Research Laboratories. He served at the Baton Rouge refinery until his transfer to New York last September. He obtained his Ph.D in chemistry at M.I.T. and did his undergraduate work at Lynchburg College.

At the Baton Rouge refinery **Ralph D. Patch,** head of the petroleum products division, has taken an executive assignment as advisor to the management of the Hamburg Refinery of Esso A.G. in Germany. He has been succeeded at Baton Rouge by **D. M. Cox,** formerly head of the refinery's technical division.

Dr. R. K. Dix, head of the crude and product coordination department, has taken Cox's post in the technical division.

At the Bayway refinery, **Ralph Cardello** has been appointed head of the process evaluation group of the refinery economics section. He was formerly acting head of the hydroforming group in the process engineering section.

Cliff Anderson, Tony Decker, and **Harry Reibel** have been promoted from stillmen in the cracking department to foremen in the cracking and light ends division. **Jim Mitchell** has been advanced from operator to foreman in the gas plant.

Henry J. Ogorzaly, assistant director of Esso Research and Engineering Co.'s petroleum development department, has been assigned to follow the firm's nuclear activities as they relate to chemical and petroleum processes and products.

Edward J. Gornowski has been appointed assistant director of the petroleum development division. He was appointed a section head in the division last November.

A. P. Moss has been appointed industrial chemicals production manager for Carbide and Carbon Chemicals Co. He was formerly superintendent of chemicals and resins at the South Charleston, W. Va., plant, a post that has now been given to **W. W. TenEyck.**

Max Hill has been made production manager of fine chemicals. He was assistant superintendent at South Charleston. Both Moss and Hill have relocated in New York.

In the research department **Dr. W. N. Stoops** has been appointed associate director. **Dr. H. C. Chitwood, B. J. Cottrell, Dr. Benjamin Phillips, G. M. Powell,** and **A. T. Walter** have been named assistant directors. **Dr. D. M. Young** has been appointed assistant to the director of the research department and will be located in the New York offices.

A. K. Doolittle has been named senior scientist. He will direct a broad program of basic research in liquid-state physics. Doolittle was appointed assistant director of research in 1944.

A. R. Dudley has been promoted to senior chemical engineer in the technical service division of Humble Oil & Refining Co.'s Baytown refinery. Dudley holds a B.S. in chemical engineering from the University of Texas.

Dr. T. S. Leary has been appointed manager of Cities Service Research and Development Co.'s process development laboratory at Lake Charles, La.

Leary received his B.S. and M.S. in chemical engineering at Rensselaer Polytechnic Institute and his Ph.D. at Iowa State University.

Dr. Kasch

Mr. Feuchter

Dr. John E. Kasch has become manager of manufacturing coordination for the American Oil Co. He was technical assistant to the vice-president of manufacturing for the last two years.

Charles F. Feuchter has been appointed manager of planning in the manufacturing department.

Kasch joined the company's refining affiliate at Texas City in 1942 as a chemical engineer. He was transferred to New York in 1952 to serve

as technical assistant to the president of the refining affiliate.

Kasch holds B.S., M.S. and Ph.D. degrees from the University of Texas.

Feuchter began with Amoco's parent company, Standard of Indiana, in 1935 as a chemical engineer. He went in 1938 to the refining affiliate of Amoco at Texas City and moved in 1942 to New York. He worked during this time in manufacturing.

Feuchter holds B.S. and M.S. degrees from M.I.T.

Mr. Jackson

Mr. Baker

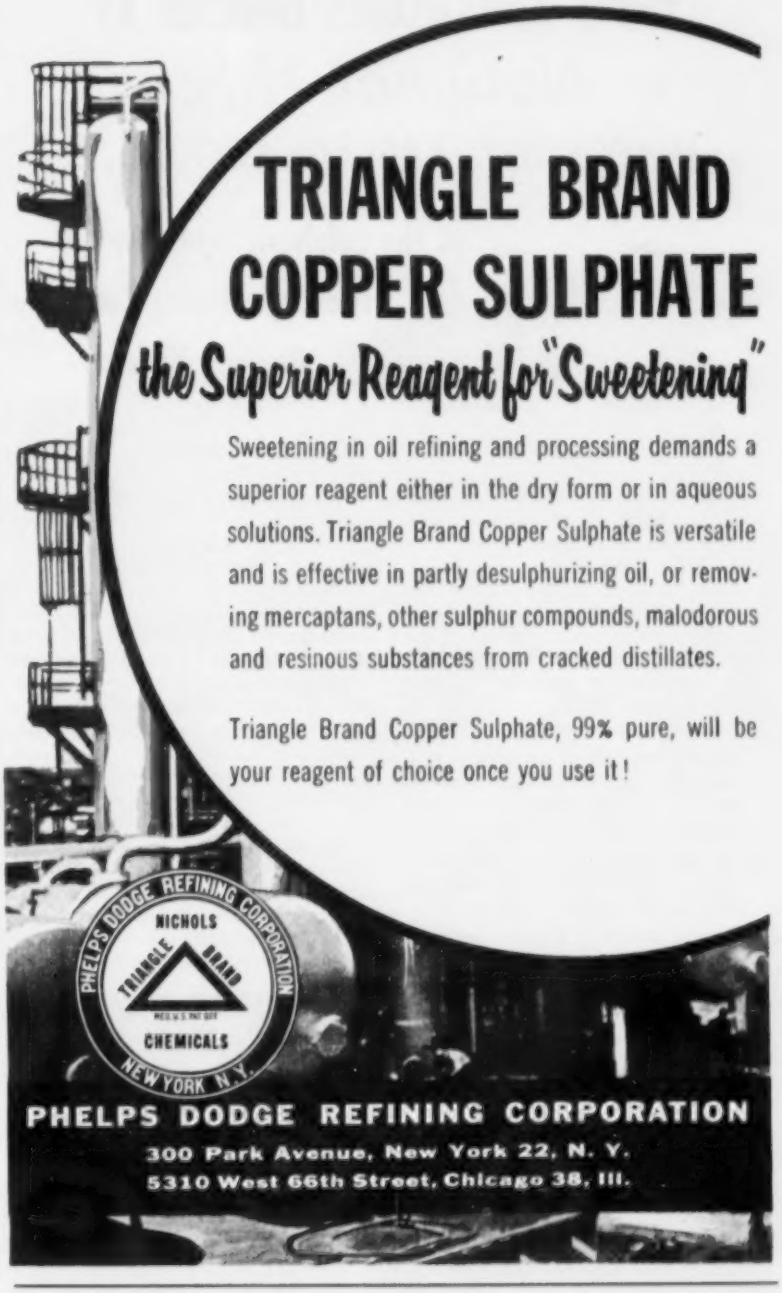
R. Rea Jackson has been appointed general manager of Socony Mobil Oil Co.'s manufacturing department and chairman of the manufacturing committee. The latter post was relinquished by George S. Dunham, director and executive in charge of manufacturing.

Charles P. Baker succeeds Jackson as director of manufacturing for Mobil Overseas Oil Co. Baker has been manager of domestic refining operations and vice-chairman of its manufacturing committee.

Jackson began in the oil industry with Magnolia Petroleum in 1923 as a chemist. He became superintendent of the Beaumont refinery in 1936, and a year later he was appointed manager of Socony's Paulsboro refinery. In 1950 he was transferred to New York as a member of the manufacturing committee.

Baker also began in the industry at Magnolia's Beaumont refinery. Two years later, in 1936, he worked at the laboratories of Houdry Process Corp. and Socony, returning to Beaumont in 1937. On his release from the Army in 1946, Baker was named general superintendent and later manager of Socony's East St. Louis refinery. In 1952 he was transferred to New York as a member of the manufacturing committee and became vice-chairman the following year.

William A. Burns has succeeded **Edward R. Grey** as plant manager of the Savannah refinery of American Oil Co. Grey has been made plant man-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Sweetening in oil refining and processing demands a superior reagent either in the dry form or in aqueous solutions. Triangle Brand Copper Sulphate is versatile and is effective in partly desulphurizing oil, or removing mercaptans, other sulphur compounds, malodorous and resinous substances from cracked distillates.
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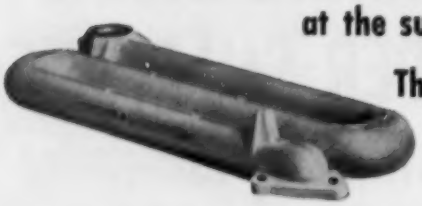
PETROLEUM PROCESSING—Subscription Department
330 West 42nd Street—New York 36, N. Y.

(To obtain more data on advertised products see page 182)

TRIPLE ADVANTAGES EFFECTED BY *National-U.S.* EVAPORATIVE CASCADE COOLERS...



at the sulphuric acid plant of The Eagle-Picher Company Galena, Kansas

A unique installation of National-U.S. large evaporative cascade type coolers is solving the cooling problem for The Eagle-Picher Company in the manufacture of sulfuric acid at Galena, Kansas.

Each cooling unit combines the water cooling principles of a conventional wood tower with the heat exchanger principle of National-U.S. cast iron cooling sections through which the acid flows.

The advantages are three-fold:

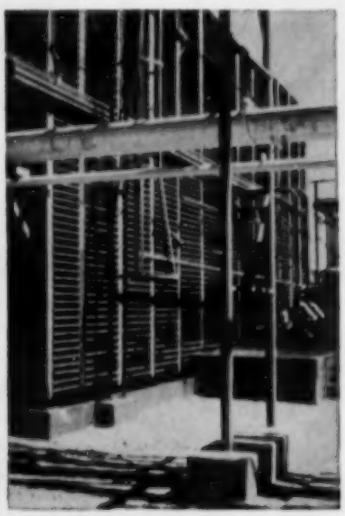
1. **SAVES WATER in an area where water is scarce—makeup quantity equal to evaporation and blowdown losses only.**
2. **SAVES SPACE—takes up little more room than a conventional raw water cooling system.**
3. **SAVES IN FIRST COST—because of reduced space and by eliminating a separate cooling tower.**

The entire cooling area is blanketed with spray from a series of jet nozzles forming a checkerboard umbrella of water over the coolers and pit. Water circulation quantity is two-and-a-half times that of a conventional installation. A proportionate cooling effect is exerted on the heated water from the heat transfer surface, plus considerable evaporative effect from warm water on the surface of the sections.

Over two years of operating experience has proved the efficiency and the triple advantages of this installation of coolers designed by National-U.S. engineers.

For full information, get in touch with National-U.S. Heat Transfer Division, whose engineers will also be glad to discuss your particular cooling problems with you.

Exterior view of the coolers at Galena, Kansas sulfuric acid plant of The Eagle-Picher Company. Note the resemblance to a conventional cooling tower. Circulating water pumps can be seen at the left.



Looking down on water sprays in operation at the evaporative cooler. (Installation was made by Leonard Construction Co., Chicago.)

HEAT TRANSFER DIVISION

National-U.S. Radiator CORPORATION

HEAT TRANSFER DIVISION HEADQUARTERS
342 Madison Avenue, New York 17, New York

ager of the Baltimore refinery, replacing **William W. Hulin,** who is retiring.

Burns joined Amoco in 1943 and has held a supervisory post at Savannah since 1952. Grey has been with the company since 1933, and has been in charge of the Savannah refinery since 1952.

Mr. Wood

Mr. Copeland

James T. Wood, vice-president over foreign operations for The Texas Co. since 1950, has been made vice-president for the company. He succeeds **T. H. Webb,** who has retired after 33 years with the company.

The general manager of foreign operations, **Harris T. Dodge,** has been promoted to vice-president of foreign operations.

Frank M. Dawson, who was manager of Texaco's purchasing department, has been appointed vice-president in charge of the supply and distribution department.

In the refining department, **William G. Copeland** has been appointed manager of the operations division in New York City. He succeeds **Howard S. McCray,** who has been named manager of the purchasing department. Copeland was last general superintendent of the Port Arthur works, a post he was given in 1954. This post is now held by **Henry Flynn,** and **H. E. Fouts** has been named to succeed him as superintendent of manufacturing at the works. Fouts was moved up from assistant superintendent.

J. W. Morgan has been appointed to British American Oil Co.'s new post of general manager of manufacturing. Morgan has been in refining operations since joining the company at the Calgary refinery in 1939. He has been assistant manager of manufacturing at the head office for the past two years.

Robert E. Yancey has been elected vice-president of refining for Ashland Oil & Refining Co. Previously he was general superintendent of refineries.

He began with Ashland in 1943,

(To obtain more data on advertised products see page 182)

after his graduation from Marshall College with a degree in chemical engineering. He has been successively technical service engineer, process engineer, shift superintendent, operating superintendent of both Catlettsburg, Ky., refineries, refinery coordinator, and then general superintendent of refineries.

Walter Henry Nelson has succeeded **Eloise Michel** as editor of the American Petroleum Institute Quarterly. Nelson has been a member of the information department staff for the past year. Miss Michel has retired from service with the API.

Harry F. Ahern, manager of Hercules Powder Co.'s Mansfield, Mass., plant, has been appointed assistant director of operations of the synthetics department.

John Z. Miller, technical assistant to the director of operations, has been given the new post of manager of engineering.

Succeeding Ahern at Mansfield is **Harold R. Monfort,** who has been technical assistant to the director of operations of the synthetics department since 1948.

Paul D. Barton has been named Sun Oil Co.'s director of engineering. **George M. Closs** becomes associate director. Barton was chief engineer of the manufacturing department and, before 1947, assistant chief engineer of the engineering division.

Closs was manager of Sun's Toledo, Ohio, refinery. This post has now been given to **John F. Harron,** formerly the refinery superintendent.

Herbert C. Thober, who was operating assistant in the distillates and cracking division at Toledo, has been made refinery superintendent.

Arnold F. Kaulakis, employee relations manager for Esso Research and Engineering Co., was incorrectly described in the Personals of the December issue. He has been with Esso Research since 1942 and became assistant director of the petroleum development division. Before his recent transfer to employee relations, he served as acting director of the division. Kaulakis is a 1938 chemical engineering graduate of M.I.T. and joined the refining industry in Texas the same year.

The description carried in this space in December belonged to Dr. George M. Maverick, whom Kaulakis succeeded in employee relations.

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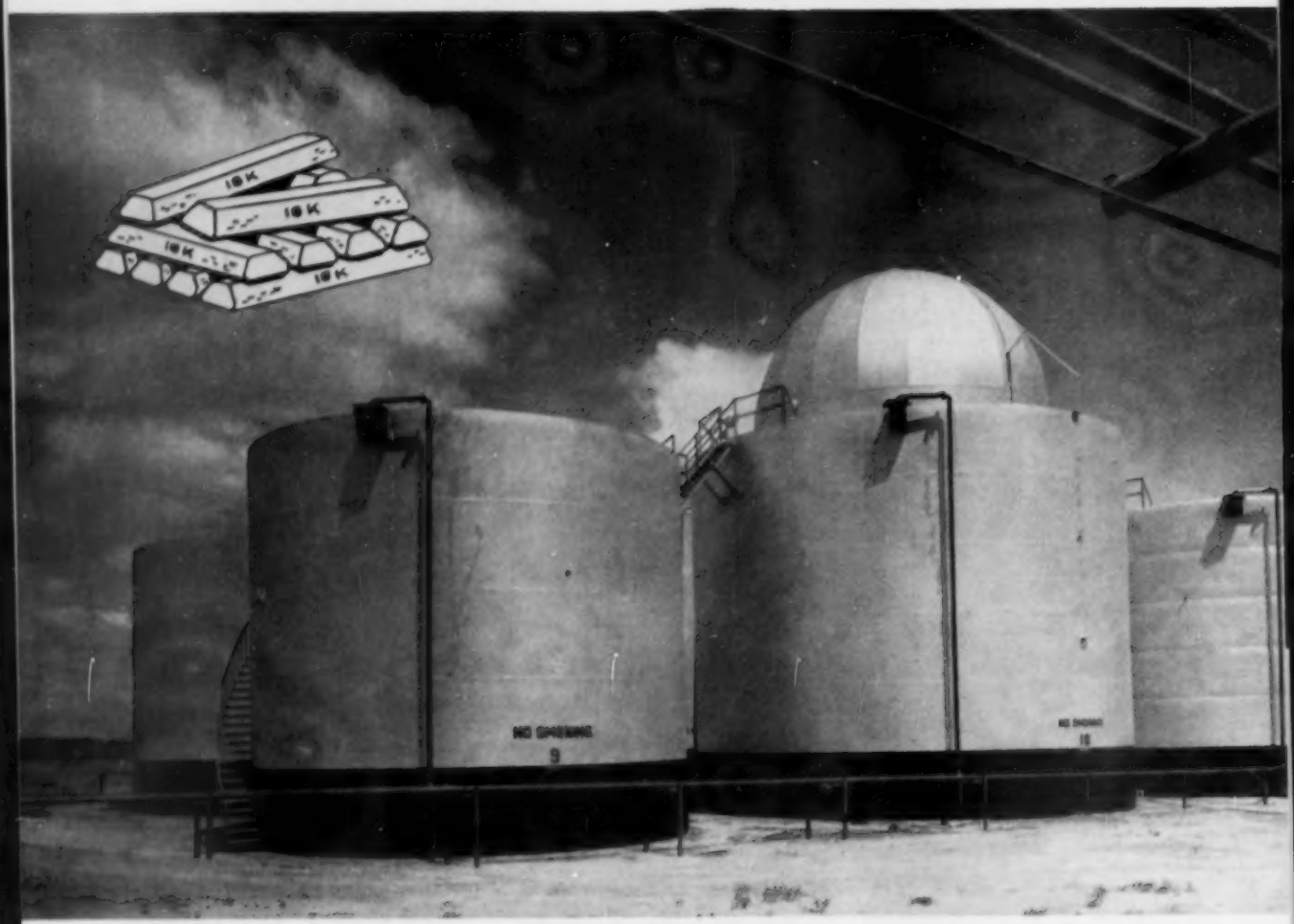

like Volatile Hydrocarbons

● Would you just sit and watch it go? That's exactly what's happening every time one of your fixed-roof tanks, that store volatile hydrocarbons, vents vapor to the atmosphere. Profits are disappearing if you're just sitting and watching. A Hortondome® Roof, like the one above, acting as the central unit in a vapor conservation system and interconnected to fixed-roof tanks, will store displaced vapor from the tanks under a flexible hemispherical membrane inside the dome. When conditions causing the displacement are reversed, the vapor will return to the tanks . . . and return profits to you. Complete information on Hortondome Roofs may be obtained by writing our nearest office.

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Plants in
BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

GE Enters Computer Field

Newest entry in the field of industrial computers is the General Electric Co. Although GE has been making computers for specialized engineering and military purposes for some time, the firm hasn't until now produced a full line for industrial use. Several moves are being made concurrently with this decision:

1–Existing computer activities are being centralized in a new industrial computer section.

2–Engineering, marketing and sales units are being organized in the new section.

3–An advanced development engineering program is being fashioned to fit the section's requirements.

4–Four men have been appointed to manage the major functions of the new section: H. R. Oldfield, Jr., to general manager, Kenneth R. Geiser to manager of engineering, Clair C. Lasher to manager of marketing, and George C. Trotter to sales manager. The managers are now staffing a full-scale operating section.

Once under way, the section will manufacture and sell all types of computers—analog, digital, and simulators—as well as special components for computing equipment. They will range in size from the smallest types used for production control to giant machines capable of the most intricate tasks now given to computers.

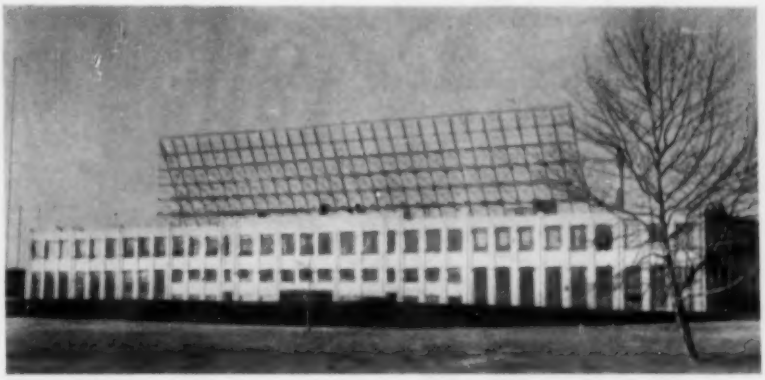
Dunkak Gets New Selas Post

Selas Corp. of America has given Elmer B. Dunkak the newly created post of vice-president of sales. Mr. Dunkak brings to Selas more than 20 years' experience in combustion and process equipment work.

Mr. Dunkak

For the past 18 months Mr. Dunkak has served as consultant to the president of Selas. Prior to joining the company, Mr. Dunkak was engaged in private engineering practice specializing in management problems relating to products and marketing.

He has also been associated with C. M. Kemp Manufacturing Co. as vice-president and general manager, and with Davison Chemical Corp. as vice-president of engineering.



PROCESS DEVELOPMENT and pilot plant operation at the Lummus Co. will be concentrated in this building at Newark, N. J. The 10½-acre site was recently purchased by Lummus to function as an engineering research center.

New NACE Officers

President of the National Association of Corrosion Engineers for 1956-57 is W. F. Fair, Jr., Tar Products Division, Koppers Co. Vice-president is W. H. Stewart, Sun Pipe Line Co.; and R. A. Brannon, Humble Pipe Line Co., was re-elected treasurer.

Three new directors are H. L. Bilhartz, Production Profits, Inc.; Hugh Hamilton, A. V. Smith Engineering Co.; and A. L. Stegner, Tennessee Gas Transmission Co.

Davison Builds Research Lab

Davison Chemical Co. is building a new laboratory for its expanding research activities. The site is about midway between Baltimore and Washington, D.C., near the Johns Hopkins University applied physics laboratory. The three story building will enclose 52,000 sq. ft. and provide for a staff of 160 professional and supporting workers. It is expected to be finished during 1956.

Departments to be moved to the new location from Davison's main research center in Baltimore include: research management; chemical, agricultural, catalyst, and nuclear research; and new products' development. Process engineering research will continue at Baltimore.

Plan to Market PVC Pipe

Polyvinyl chloride plastic pipe will be marketed in seven western states by the Columbia-Geneva Division of United States Steel. Distributors are now being appointed.

The new lightweight piping material is being manufactured by U.S. Steel's National Tube Division. It is rigid and unplasticized. Two types will be distributed—normal impact and high impact—in sizes from ½-in. through 4 in. In addition, sizes up to 6 in. will be extruded to order.

The PVC pipe will be sold and serviced principally by existing steel pipe and specialty tubing distributors.

Badger Elects Broggini

A. J. Broggini has been elected executive vice-president and chairman of the executive committee of Badger Manufacturing Co. He has been a board member since March of 1955 and has served on the executive committee since September of the same year.

Mr. Broggini

Before joining Badger Manufacturing in 1952, Mr. Broggini was with E. B. Badger & Sons, which he joined in 1937. Here he served in various engineering, sales and executive capacities.

Mr. Broggini is a chemical engineer, with a degree from the University of Michigan Class of 1934.

Personnel Changes

Foxboro Co.—E. W. Prendergast, formerly branch manager at Atlanta, to regional manager of the southeast territory; R. F. Sutton, from the Pittsburgh sales office to Pensacola, Fla.; F. J. Stevens, Jr., to the Lakeland, Fla., branch; H. C. Craig, to Jackson-

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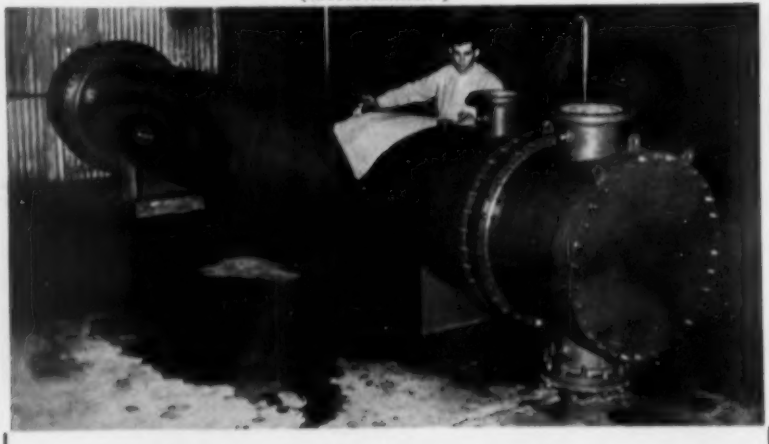

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Just 5 weeks after initial order, a KEMCO inspector confirms all specifications on a 4,000 sq. ft. heat exchanger designed and constructed by Krueger Engineering and Manufacturing Company for a major gulf coast petrochemical company.

If your problem is getting heat exchangers fast enough to meet production deadline, KEMCO can give you this same fast service —faster than any other company.

Get in touch with KEMCO at P. O. Box 1644, Houston 1, Texas. They're the industry's fastest.

ville, Miss., as branch manager; L. C. Estes, to the Atlanta branch; G. W. Reed, Jr., has been named manager of the New Orleans office; J. K. Younkins to manager at Charleston, W. Va.

Dow Chemical Co.—Preston C. McCutcheon, supervisor of dry cleaning solvents since 1943, to Dow's sales training program; Carl C. Castle, formerly on the organic chemicals sales staff, has succeeded McCutcheon.

Condenser Service & Engineering Co.—Leon D. Thompson, formerly specialist with Dorr-Oliver, Inc., to filtration engineer with the Blackburn-Smith Division of Condenser Service.

Norton Co.—Milton P. Higgins and George N. Jeppson were re-elected president and chairman of the board, respectively; William R. Moore, a director and vice-president of national accounts has retired; Edwin C. Evans has been elected a director.

National Research Corp.—Richard A. Knight to assistant to the general manager, coordinating activities of sales, engineering and production departments.

Hooker Electrochemical Co.—Thomas E. Moffitt to executive vice-president and a director; R. Wolcott Hooker to senior vice-president.

Worthington Corp.—Elston J. Tribble, formerly assistant vice-president of manufacturing, to vice-president; Aloysius M. Tullo to vice-president, continuing as general manager of the Harrison division.

Vitro Corp of America—Thomas M. Lumly, president of the Refinery Engineering Co. of Tulsa, now an operating division of Vitro, to director.

Rhodia, Inc.—Frank J. Milo to sales representative of industrial reodorants for the Alamask division.

C. W. Nofsinger Co.—John S. Rearick to vice-president. He has been manager of engineering since joining Nofsinger in 1954. Before, he was with M. W. Kellogg Co. for 16 years.

Branches, Distributors

Wolverine Tube Division of Calumet & Hecla has opened a sales office in Charlotte, N. C., at 127 W. 7th St. George Overstreet, area sales representative, will have his headquarters there.

(To obtain more data on advertised products see page 182)

THESE ADDITIVES ARE NOT ON THE PUMP BUT THEY TOO MEAN "PERFORMANCE"

Tenamene

EASTMAN GASOLINE ADDITIVES

Though unidentified at the point of final delivery, the presence of these additives is vital to the dependable performance of gasoline. For help in the careful selection and economical use of these gum-inhibiting additives, call on Eastman's highly qualified petroleum specialists.

For more information on Tenamene additives and the service that backs up their proper use, contact our local representative or write to Eastman Chemical Products, Inc., Kingsport, Tennessee – a subsidiary of Eastman Kodak Company.

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tennessee; New York—260 Madison Ave.; Framingham, Mass.—65 Concord St.; Cincinnati—Carew Tower; Cleveland—Terminal Tower Bldg.; Chicago—360 N. Michigan Ave.; St. Louis—Continental Bldg.; Houston—412 Main St. **West Coast: Wilson Meyer Co.,** San Francisco—333 Montgomery St.; Los Angeles—4800 District Blvd.; Portland—520 S. W. Sixth St.; Salt Lake City—73 S. Main St.; Seattle—821 Second Ave.

(To obtain more data on advertised products see page 182)

REFINER'S GUIDE—for using Du Pont Metal Deactivator

APPLICATIONS	BENEFITS
Motor Gasoline	Protects your high octane gasoline by preventing copper-caused gum, often a source of customer dissatisfaction. Du Pont Metal Deactivator may also provide important savings when used with other Du Pont additives.
Kerosines	DMD is useful as a color stabilizer in some copper-sweetened stocks. It has also been reported effective in reducing carbon and coke formation in pot burners by as much as 50%.
Jet Fuels	DMD has been approved by military specification (MIL-F-5624C) for use in jet fuels to inhibit deterioration, thereby decreasing fuel system plugging and residue formation.
Diesel Oils, Home Heating Oils	DMD helps prevent color deterioration, improves storage stability, inhibits formation of gelatinous sludge due to copper pickup.
Turbine Oils	The advantages vary according to service.
Greases	Displays benefits in greases for bearings which may have copper content. It is frequently used in conjunction with a Du Pont antioxidant.
Special Applications	DMD counteracts the catalytic effect of metals on gasolines during long storage periods, and this is especially important for stabilizing "driveaway" gasolines.

If you use, or have need for, metal deactivator, why not make use of Du Pont Technical Services?

Are you benefiting from the advantages of using metal deactivator in all possible applications?

Are you getting the *most* product improvement from the metal deactivator you are now using?

Can you get improved benefits at lower cost with combinations of Du Pont Metal Deactivator plus other special-purpose additives?

No one can give you snap answers to these and other important questions regarding the prevention of metal catalyzed gum formation. But you can get accurate information easily from the Du Pont regional laboratories. There are five in all and one is conveniently near you.

The service representatives at these Du Pont laboratories will be glad to work with your staff on your own particular products and problems. Because combinations of DMD with other Du Pont additives so often bring greatly increased benefits, Du Pont technical people are especially well-equipped to help you. They may, for example, be able to show you how a combination of different additives can cut the total additive content you need . . . possibly give added effectiveness, at less cost.

To explore these interesting possibilities, contact your Du Pont Petroleum Chemicals Division representative. He'll be glad to work out a program of technical assistance to fit your individual needs. Just call him at one of the sales offices listed below.

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LOS ANGELES, CAL.—612 So. Flower St. ..... Phone MAdison 5-1691
NEW YORK, N. Y.—1270 Ave. of the Americas . . Phone COlumbus 5-2342
PHILADELPHIA, PA.—3 Penn Center Plaza ..... Phone LOcust 8-3531
PITTSBURGH, PA.—Room 510, Alcoa Bldg. ..... Phone ATlantic 1-2933
SAN FRANCISCO, CAL.—Room 626, 111 Sutter St., Phone EXbrook 2-6230
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By Peter J. Gaylor, Patent Attorney, Elizabeth, N. J.

Activating Ion Exchangers Boosts Capacity for Mercaptan Removal

THE limiting factor in the sorption of ionic materials by ion exchange resins is the limited capacity of the various ion exchangers. For example, one anion exchange material available at the present time has a capacity limited to the treatment of only 11 volumes of gasoline containing 0.1 wt./% mercaptan sulfur per volume of exchange material. Furthermore, the effluent gasoline has a rather high mercaptan sulfur content, about 0.004%. In addition, the higher molecular weight mercaptans (C_8-C_{12}), such as are found in the kerosine fraction, are not so readily extracted.

In U. S. Patent No. 2,718,489, issued to Socony Mobil Oil Co. there is disclosed a method for activating such ion exchange materials to avoid the disadvantages outlined above. Fresh or regenerated ion exchange resin can be activated by contacting (submersion, percolation, etc.) the exchange material with one or a mixture of the lower molecular weight monohydric alcohols, such as methanol, ethanol, propanol, or in general, with an ilphatic monohydric alcohol having 1 to 5 carbon atoms.

Such an activation is claimed to produce an ion exchange resin that is more efficient in the removal of sulfur from gasoline. This is shown by the fact that the residual mercaptan sulfur of the treated gasoline is 0.0002%, compared to 0.004%. Also, the capacity of a given volume of exchange material for the removal of acidic constituents, particularly mercaptans, is greatly increased—by as much as 340% over unactivated material. Furthermore, it is stated that activated material will extract kerosine mercaptans as well.

Suitable procedures for using an anion exchange resin include the following. When starting with fresh anion exchange material which is received from the supplier in the form of a salt of a strong acid (for example, as the chloride), the exchange material is treated with an aqueous solution of an alkali metal hydroxide. It has been found that treating one volume of exchange material in the chloride form with 40 volumes of 4% aqueous sodium hydroxide solution converts the exchange material (for example, Rohm, and Haas Amberlite IRA-400) to the hydroxyl form.

When starting with the exhausted or partially exhausted anion exchange resin, it is first regenerated, preferably as described above.

An anion exchange material in the hydroxyl form is washed, when desirable or necessary, with water which is itself substantially free from anions, until the washings are neutral. But absolute neutrality is not essential. The exchange material is then ready for the treatment of non-aqueous solutions. However, greater efficiency of extraction can be obtained by activating the exchange resin with a monohydric alkanol having 1 to 5 carbon atoms as already described.

When cation exchange material is exhausted or partially exhausted the exchange resin is regenerated. The regenerated cationic exchange resin is then activated by treatment with a monohydric alkanol or a mixture of monohydric alkanols having 1 to 5 carbon atoms.

Activation of fresh cationic exchange resins is likewise obtained by treatment with a monohydric alkanol having 1 to 5 carbon atoms.

In the case of Amberlite XE-75 resin, the capacity of the (ethanol) activated material was 37 volumes of gasoline per volume of resin. The gasoline was reduced from 0.10% mercaptan sulfur to a final cut-off value of 0.005 wt/% mercaptan sulfur, compared with a capacity of 11 for the unactivated resin.

Patents Issued Recently

The following listing gives the patent number, patentee, or assignee, and a brief description of patents of interest to the petroleum processing industries in the Official Gazette of the U.S. Patent Office for Dec. 20, 27, and Jan. 3 and 10, 1955-6, Vols. 701 and 702, Nos. 3, 4, and 1, 2.

PROCESSES

Refining

2,727,367 (Standard Oil Co.-Ind.) Dehydrated liquified petroleum gas production, using adsorbent.

2,727,731 (Pure Oil Co.) Vessel for increasing the efficiency of mixing, having protuberant flow passage vertically disposed along side.

2,727,792 (Phillips Petroleum Co.) Pebble gas lift.

2,727,847 (Sinclair Refining Co.) Process for recovering resins from petroleum fractions, using liquid propane.

2,727,848 (American Oil Co.) Aromatic solvent recovery in solvent extraction, using triethylene glycol solvent.

2,727,849 (Standard Oil Co.-Ind.) Sweetening of catalytically cracked naphthas with alkali, alkyl phenol, oxygen, and sulfur.

2,727,850 (Standard Oil Co.-Ind.) Sweetening process, using water.

2,727,851 (Standard Oil Co.-Ind.) Refining of heater oil with liquid SO_2.

2,727,852 (Standard Oil Co.-Ind.) Doctor sweetening promoted by a copper salt.

2,727,853 (Pure Oil Co.) Process for refining of petroleum, shale oil, and the like, by propane deasphalting, coking residue, etc.

2,727,854 (Standard Oil Co.-Ind.) Recovery of naphthalene from petroleum fractions.

2,728,641 (Standard Oil Co.-Ind.) Temperature-responsive decanting control for decanting oil from solid catalyst-oil slurry.

2,728,708 (Esso Research & Engineering Co.) Solvent recovery.

2,728,709 (Esso Research & Engineering Co.) Use of emulsions in dewaxing oil.

2,728,710 (Union Oil Co. of Calif.) Process for hydrodesulfurizing hydrocarbons, using Co-Mo-Al_2O_3 catalyst.

2,728,711 (Universal Oil Products Co.) Process for improving storage properties of substantially sweet hydrocarbon distillates by treatment with alcohol-alkali reagent.

2,728,714 (Esso Research & Engineering Co.) Deashing hydro carbon oils by water washing.

2,728,716 (Esso Research & Engineering Co.) Adsorption process for thermally converted naphtha, using silica gel.

2,728,800 (Esso Research & Engineering Co.) Adsorption process for the separation of aromatic hydrocarbons, using silica gel.

2,729,291 (Continental Oil Co.) Separating CO_2-petroleum mixtures by shifting phase equilibrium.

2,729,543 (Union Oil Co.) Removal of sulfur dioxide from gases containing the same, by absorption in liquid which is treated with H_2S and yield free S.

2,729,589 (Esso Research & Engineering Co.) Deasphalting with propane and butane.

2,729,590 (Socony Mobil Oil Co.) Desulfurization and deoxygenation of hydrocarbon oils by contacting with I or HI at over 550° F.

2,729,591 (British Petroleum Co., Ltd.) Sweetening of petroleum oils containing mercaptans with alkali and oxygen and then with alkali, a solutizer and oxygen.

2,729,592 (Esso Research & Engineering Co.) Air sweetening process of gasoline containing cracked portions, in presence of phenylenediamine and NH_3.

2,729,593 (Socony Mobil Oil Co., Inc.) Demetalation of hydrocarbon oils with I, HI, etc.

2,729,594 (California Research Corp.) Stabilization of cracked distillate fuel oils by acid treating, caustic, etc.

2,729,595 (Socony Mobil Oil Co., Inc.) Process for removing nitrogen compounds from hydrocarbon oil with iodine or hydrogen iodide.

2,730,190 (Union Oil Co. of Calif.) Treatment of oil-containing water.

2,730,240 (Union Oil Co. of Calif.) Dehydration of oils.

2,730,485 (The Texas Co.) Separating oil-wax mixtures, using halogenated acetal solvent.

2,730,486 (Socony Mobil Oil Co.) Ion exchange removal of mercaptans from petroleum.

2,730,487 (British Petroleum Co., Ltd.) Removal of vanadium and/or sodium from petroleum and petroleum products with titania on alumina and hydrofining.

Conversions

2,727,812-3 (Universal Oil Products Co.) Production of combustible gas from comminuted solid carbonaceous material.

2,727,931 (Universal Oil Products Co.) Isomeric cycloalkylation of aromatic compounds.

2,727,932 (National Research Development Corp.) Method for controlling reactions in hot gaseous reaction mixtures, using internal combustion gas turbine as reactor.

2,727,933 (National Research Development Corp.) Partial oxidation and pyrolysis of saturated hydrocarbons within internal combustion engine.

2,728,410 (Standard Oil Co.-Ind.) Throttle valve for gases containing finely divided solids.

2,728,632 (Esso Research & Engineering Co.) Control of solids circulation within fluid-solids contacting zones.

2,728,712 (Esso Research & Engineering Co.)

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2,730,557 (Shell Development Co.) Production of alkyl aromatic hydrocarbons by cat-cracking alkylate to cumene-benzene, etc.

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2,728,650 (Gulf Research & Development Co.) Process for producing gas comprising hydrogen and CO by partial burning.

2,728,786 (M. W. Kellogg Co.) Reduction of iron oxide for use in the synthesis of hydrocarbons.

2,729,651 (Badische Anilin- & Soda-Fabrik A. G.) Process for the production of aliphatic oxygen compounds by carbonylation of alcohols, ethers, and esters.

2,729,664 (Esso Research & Engineering Co.) Hydrocarbon synthesis fluidized catalyst of reduced alpha ferric oxide and caesium fluoride.

PRODUCTS

Chemicals

2,727,861 (Sinclair Refining Co.) Method of converting an ammonium petroleum sulfonate to barium sulfonate.

2,727,862 (Socony Mobil Oil Co.) Mineral oil compositions containing polymers of alkyl N-substituted maleimides.

2,727,874 (United States Rubber Co.) Acceleration of the reaction between butyl rubber and i-methylol phenols by means of chlorinated paraffin wax and product obtained thereby.

2,727,883 (Aero Service Corp.) Method of polymerizing polyalkylene polysulfides.

2,727,920 (Standard Oil Co.-Ind.) Oxidation of mercaptans to sulfonic acids.

2,727,921 (Hercules Powder Co.) Hydrocarbon oxidation in presence of water and Co catalyst.

2,727,925 (Pure Oil Co.) Removal of volatile fatty acids from phenol.

2,727,928 (Shell Development Company) Stabilization of alkyl phenol compounds.

2,727,929 (Ethyl Corp.) Aromatization of chlorine compounds.

2,728,638 (Olin Mathieson Chemical Corp.) Process for the manufacture of carbonyl sulfide from SO_2, C and CO.

2,728,727 (Pure Oil Co.) Method and composition for inhibiting corrosion of HF, using arsenic and thiourea compounds.

2,728,742 (Esso Research & Engineering Co.) Improving quality of hydrocarbon resins by treatment with divinyl compounds.

2,728,744 (Shell Development Co.) Rapid resinifying compositions containing a polyhydric alcohol and glycidyl ethers.

2,728,752 (Standard Oil Co.-Ind.) Tertiary-butyl ethylene in ethylene polymerization.

2,728,753 (Standard Oil Co.-Ind.) Improved product separation in ethylene polymerization process.

2,728,754 (Standard Oil Co.-Ind.) Continuous ethylene polymerization with catalyst regeneration.

2,728,755 (Standard Oil Co.-Ind.) Ethylene polymerization process.

2,728,756 (Standard Oil Co.-Ind.) Di-tert-butyl peroxydicarbonate for ethylene polymerization.

2,728,757 (Standard Oil Co.-Ind.) Polymerization process with group 5a metal and metal borohydride catalyst.

2,728,758 (Standard Oil Co.-Ind.) Olefin conversion with group 6a metal oxides and reactive metal borohydrides.

2,728,770 (Phillips Petroleum Co.) Process for the production of alkenyl pyridines.

2,728,789 (Shell Development Co.) Acetylenic tertiary phosphite esters.

2,728,792 (Gulf Research & Development Co.) Demetallizing a metal carbonyl-containing gas.

2,728,798 (Standard Oil Co.-Ind.) Production of high molecular weight alcohols by improved oxo process.

2,728,799 (Ethyl Corp.) Refinement of benzene hexachloride.

2,728,801 (Esso Research & Engineering Co.) Hydrocarbon drying oil production (butadiene-styrene).

2,728,803 (Standard Oil Co.-Ind.) Separation of ethylbenzene from other C_8 aromatic hydrocarbons by extraction with HF-BF_3.

2,728,806 (Shell Development Co.) Phosphorus modified halogenated hydrocarbons.

2,729,541 (Ethyl Corp.) Preparation of metal cyanates.

2,729,599 (Esso Research & Engineering Co.) Dehydration of maleic acid to anhydride.

2,729,600 (Esso Research & Engineering Co.) Azeotropic dehydration of maleic acid to anhydride.

2,729,603 (Ethyl Corp.) Manufacture of benzene hexachloride.

2,729,609 (Shell Development Co.) Poly tert-alkyl substituted carbocyclic monocarboxylic acids in alkyd resins.

2,729,626 (Esso Research & Engineering Co.) Isoolefin-multiolefin copolymers.

2,729,652 (Farbenfabriken Bayer A. G.) Production of dehydracetic acid by polymerizing diketene in acetic anhydride.

2,729,665 (Union Oil Co. of Calif.) Dicarboxylic acids and their derivatives and production of the same from paraffin wax.

2,729,674 (Union Oil Co. of Calif.) Decarboxylation of trimellitic acid to isophthalic acid.

2,729,682 (Esso Research & Engineering Co.) Preparation of isopropanol of improved odor quality.

2,729,683 (Ethyl Corp.) Dehydrochlorination of benzene hexachloride.

2,729,684 (Ethyl Corp.) Treatment of benzene hexachloride.

2,729,685 (Ethyl Corp.) Production of high purity 1, 2, 4, 5-tetra-chlorobenzene.

2,729,686 (Ethyl Corp.) Aromatization of organic chlorine compounds.

2,729,690 (Ethyl Corp.) Synergistic stabilizing compositions for rubber.

2,729,691 (Ethyl Corp.) Synergistic stabilizing compositions for organic materials comprising a mixture of an arylamine and an alkylenediamine.

2,730,438 (The Texas Co.) Process for transporting acetylene through conduit with suspension of heat-conductive solid particles.

2,730,489 (Du Pont Co.) Use of organic nitrites to inhibit polymerization of hydrocarbons during distillation.

2,730,515 (Esso Research & Engineering Co.) Blended divinyl benzene polymers.

2,730,519 (Esso Research & Engineering Co.) Production of clear transparent polymers of isobutylene and styrene.

2,730,531 (Shell Development Co.) Amides of epoxyamines.

2,730,532 (Shell Development Co.) Epoxy-substituted esters of silicon acids and their preparation.

2,730,548 (Shell Development Co.) Method for producing polycyclic hydrocarbons containing nor-tricyclene nucleus from bicyclo—(2, 2, 1) heptadiene.

2,730,550 (Shell Development Co.) Production and stabilization of aromatic hydroperoxides.

2,730,552 (Shell Development Co.) Production of bis di-(hydroxyaryl) substituted compounds from phenol, dimethyl ketone and acid catalyst.

2,730,553 (Shell Development Co.) Production of bis di-(hydroxyaryl) substituted compounds.

2,730,555 (Texaco Development Co.) Catalyst and process for preparation of vinyl chloride.

2,730,559 (Shell Development Co.) Preparation of diallylic compounds.

Catalysts

2,727,868 (Socony Mobil Oil Co.) Preparation of catalyst from kaolin and silica gel.
2,728,715 (Tide Water Associated Oil Co.) Washing silica gel with an aqueous solution containing alkali or alkaline earth before adsorption.

Fuels

2,727,588 (Pure Oil Co.) Gas engine fuel of constant composition from demethanizer-rich oil re-absorber gas, etc.
2,728,643-7 (Tide Water Associated Oil Co.) Corrosion inhibited gasoline containing alkyl acid phosphate.
2,728,648 (Ethyl Corp.) Antiknock fluids comprising lead alkyl and soluble lithium compound.
2,728,656 (Ethyl Corp.) Method of preparing lead alloys.
2,729,936 (Phillips Petroleum Co.) Fuel for and method of operating a jet engine by injecting 5-95% 1-olefins in forward portion at F/A ratio of 0.005—.10.
2,729,948 (Olin Mathieson Chemical Corp.) Process of transfer of liquefied gas.
2,730,437 (Raymond B. Coombe) Automatic control for gas-making machines.

Lubricants

2,727,496 (Sun Oil Co.) Internal combustion engine operation, using viscous mineral oil containing powdered charcoal to lessen carbon deposits.
2,728,728 (Tide Water Associated Oil Co.) Anti-corrosion turbine oil containing alkyl acid phosphate and furfuryl amine.
2,730,436 (Esso Research & Engineering Co.) Stabilized organic compositions containing aralkylated alkoxy phenols.
2,730,499 (Esso Research & Engineering Co.) Lubricants for heavy journal bearings operating at elevated temperatures, containing fatty acid, substituted succinic acid and antioxidant.
2,730,500 (Esso Research & Engineering Co.) Anti-oxidants (N-acyl-p-amino resorcinol to inhibit di-2-ethylhexyl sebacate).
2,730,501 (Socony Mobil Oil Co., Inc.) Mineral oil compositions having stabilized low pour points, containing chlorwax-phenol condensate benzoate.

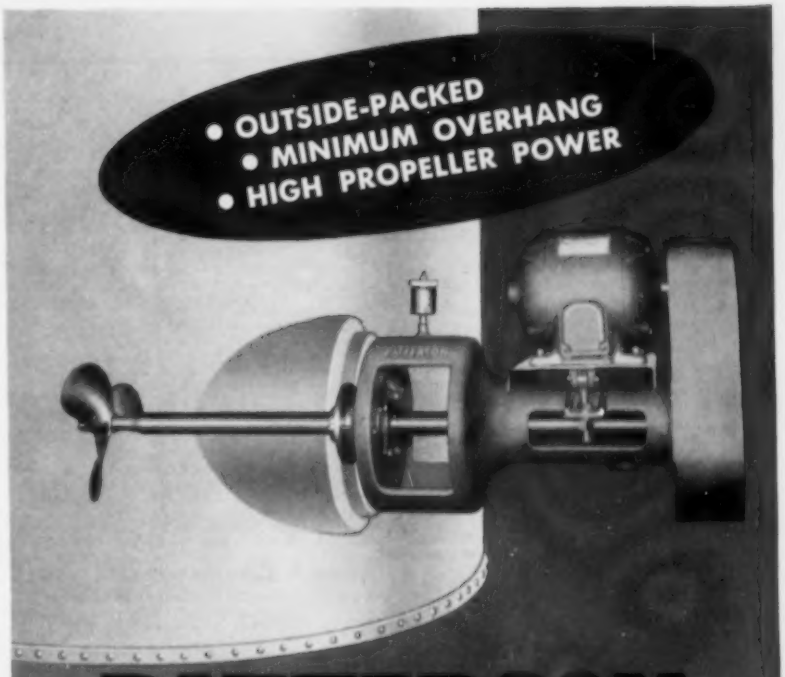
Specialties

2,727,860 (Celanese Corp. of America) Textile lubricants containing mineral oil, alkyl phenol, castor oil ester, etc.
2,728,682 (Standard Oil Co.-Ind.) Asphalt compositions containing polyamine-acid pitch product.
2,728,684 (California Research Corp.) Stable emulsions of lower molecular weight polybutenes.
2,730,452 (Shell Development Co.) Wax composition and an article coated therewith (microcrystalline wax).
2,730,454 (Shell Development Co.) Asphalt compositions and method of preparing same, having colloidal clay with base exchange properties.
2,730,476 (Sun Oil Co.) Laminated sheet material of regenerated cellulose and wax.
2,730,498 (Celanese Corp. of America) Textile lubricants.
2,730,506 (Shell Development Co.) Asphalt emulsions containing naphthenates.
2,730,510 (Shell Development Co.) Drying composition resistant to gas checking and frosting.

EQUIPMENT

Processing, general

2,727,810 (Universal Oil Products Co.) Apparatus for conversion of fluid reactant streams in the presence of subdivided particles maintained in dispersed suspension.
2,727,853 (Pure Oil Co.) Differential pressure reactor and distilling apparatus.
2,728,406 (National Tank Co.) Low temperature separation processes and units.
2,728,457 (Atlantic Refining Co.) Phase separation process and apparatus.
2,728,561 (A B Svenska Flaktfabriken) Heat exchanger.
2,728,640 (Pietro Guareschi) Construction of chemically resistant reaction towers.
2,728,641 (Standard Oil Co.-Ind.) Temperature-responsive decanting control.
2,728,642 (Tide Water Associated Oil Co.) Gas-solids contacting apparatus.
2,728,690 (Olin Mathieson Chemical Corp.) Spe-



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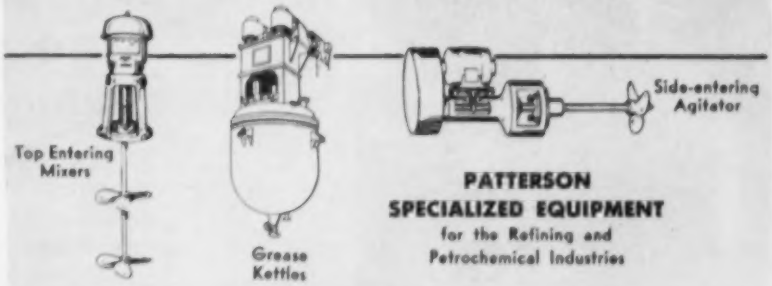

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cific gravity control apparatus and method for using it.
2,728,722 (Howe-Baker Co.) Devices for the purification of refined petroleum oils.
2,729,200 (William Joseph Miller) Liquid heater.
2,729,209 (William Joseph Miller) Apparatus for handling asphalt.
2,729,239 (Ethyl Corp.) Protective fluid pressure system.
2,729,330 (Houdry Process Corp.) Elutriation system.
2,729,430 (Alco Products, Inc.) Heat exchanger.
2,729,432 (A.O. Smith Corp.) Large capacity heat exchanger.
2,729,433 (A.O. Smith Corp.) Heat exchanger with removable tube banks.
2,729,544-5 (Shell Development Corp.) Contact apparatus with rotating discs.
2,729,546 (Cardox Corp.) Apparatus for producing inert gases.
2,729,547 (Phillips Petroleum Co.) Solids flow control apparatus.
2,729,548 (Phillips Petroleum Co.) Pebble heat exchanger chamber.
2,729,549 (Shell Development Co.) Method and apparatus for contacting and separating liquid phases by settling.
2,729,550 (Shell Development Co.) Method and apparatus for contacting liquids by reciprocal dispersion.
2,729,552 (Esso Research and Engineering Co.) Process of contacting gasiform carbonaceous solids.
2,729,737 (Societe Anonyme de Saint-Gobain) Method and means for localizing heat and reactions in limited portions of fluid bodies.
2,729,953 (Air Products, Inc.) Air fractionating cycle and apparatus.
2,730,488 (Universal Oil Products, Inc.) Liquid bath continuous conversion coking process and apparatus.

Catalytic Reactors

2,727,930 (Shell Development Co.) Process and apparatus for effecting vapor phase reactions with powedered catalyst.

Instruments

2,728,035 (Smiths America Corp.) Liquid contents gages.
2,728,070 (William D. Kelly) Liquid level tester.
2,728,218 (Atlantic Refining Co.) Apparatus for measuring solids entrained in gases.
2,728,219 (National Research Development Corp.) Means for measuring the density of a fluid.
2,728,225 (Herbert E. Skibitzke) Thermal flowmeter.
2,728,226 (King-Seeley Corp.) Deep tank liquid level indicating apparatus.
2,728,231 (Phillips Petroleum Co.) Pressure measuring device.
2,728,893 (National Luchtvaartlaboratorium) Flowmeter.
2,729,097 (Societe Anonyme des Manufactures les Glaces et Produits Chimiques de Saint-Gobain) Apparatus for analyzing gases.
2,729,102 (Phillips Petroleum Co.) Flowmeter.
2,729,103 (Vitro Corp. of America) Means for rejecting no-flow signals in a flowmeter.
2,729,135 (Boeing Airplane Co.) Refractometer for liquids.
2,729,137 (Bausch & Lomb Optical Co.) Refractometer with linear scale.
2,729,970 (Standard Oil Co.-Ohio) Carbonization testing apparatus.
2,729,976 (John H. Laub) Thermal flowmeter.
2,730,123 (Sun Oil Co.) Tank float.

Pumps & Compressors

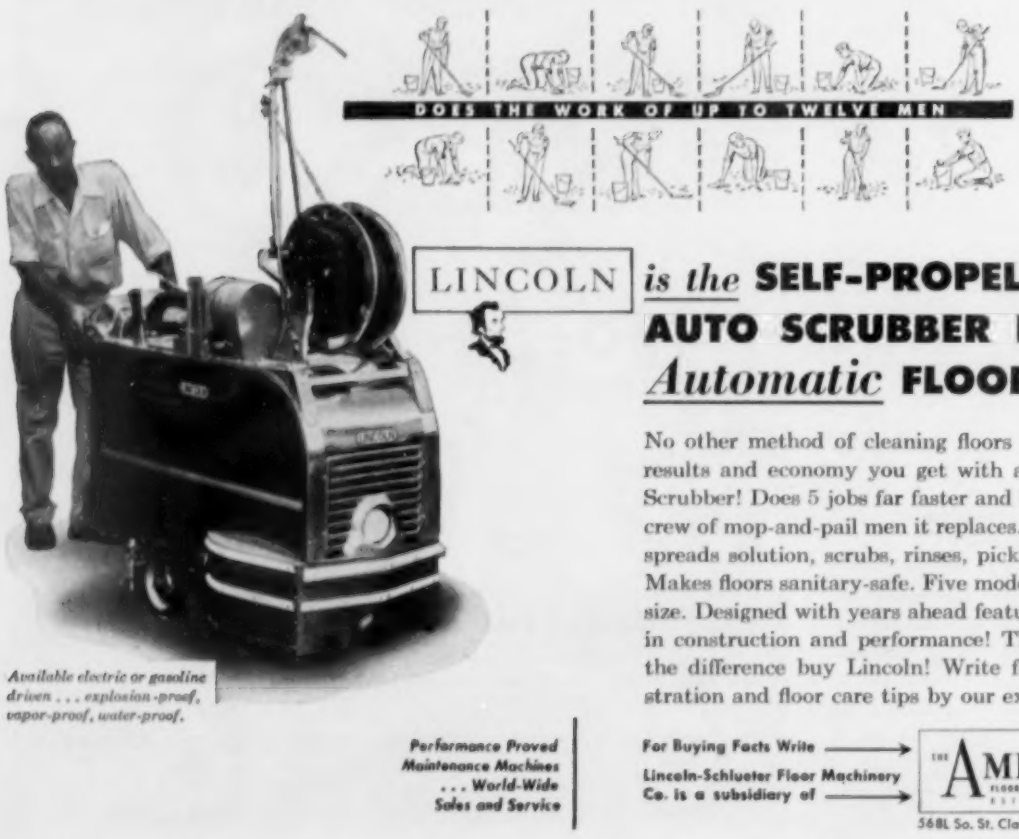
2,727,465 (Societe Nouvelle des Etablissements Brandt) Rotovolumetrical pump.
2,727,466 (Technicon International) Pump.
2,727,468 (Joy P. Rykken) Pump.
2,728,300 (Aero Supply Mfg. Co.) Gear pump.
2,728,301 (Lindberg Trust) Gear Pump.
2,728,303 (Andrew W. Tiefenthaler) Internal combustion pump.
2,729,165 (Martin W. Kremer) Rotary pump.

Valves & Fittings

2,727,529 (Borg-Warner Corp.) Relief valve.
2,727,530 (Grove Valve & Regulator Co.) Regulator valve.
2,727,531 (Durable Mfg. Co.) Valve guards.
2,727,532 (L.M. Sousa and Charles Merlin) Pressure regulating valves.
2,727,533 (Milton Roy Co.) Valve system.
2,727,715 (John B. Tuthill) Valve structure.
2,727,763 (Michel Bergman) Pipe connector for threadless pipe.
2,728,349 (Walworth Co.) Gate valve.
2,728,350 (Francis G. Hutchens) Fluid pressure regulator.
2,728,549 (Walworth Co.) Gate valve.
2,728,550 (Duriron Co.) Valve for corrosive fluids.
2,728,551 (Glenn R. Blackman) Plug valve with sealing means.
2,729,095 (Greer Hydraulics) Test equipment for oil temperature regulating valves.
2,729,217 (Marman Products Co.) Valve assembly.
2,729,238 (Marman Products Co.) Valve mounting.
2,729,419 (OPW Corp.) Shock-proof loading valve.
2,729,420 (Duriron Co.) Valve for corrosive fluids.
2,729,421 (Walter S. Baer, Sr.) Cam-locked valve.
2,729,731 (Ethyl Corp.) Feed apparatus.
2,729,734 (Ethyl Corp.) Feed device for reaction vessels.
2,730,115 (McDowell Mfg. Co.) Relief valve.
2,730,116 (McDowell Mfg. Co.) Gasket valve.
2,730,124 (J. D. Buchanan) Valve.
2,730,125 (General Motors Corp.) Filter valve with deflector.

Miscellaneous

2,727,682 (Sun Oil Co.) Analog computer or analyzer.
2,728,859 (Allied Laboratories) Apparatus for irradiation of liquids.
2,727,184 (Sun Oil Co.) A monolithic metal shell structure.
2,729,472 (Samuel Pennella) Packing for condenser tubes.
2,730,673 (Union Oil of California) Magnetometer.



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Program of the API Montreal Meeting

A VARIETY of refining problems will be debated at the mid-year meeting of the American Petroleum Institute's Refining Division. The meeting, May 14-17, will be held in Montreal at the Sheraton-Mt. Royal Hotel. Here are some highlights:

- A session on electrical equipment in which a new tentative standard defining hazardous areas for electrical equipment—RP-500—will be examined by a refiner and an engineering contractor.
- A session on computers will be offered in addition to the usual session on refinery instrumentation.
- Developing engineers in refinery technology and other aspects of training will be discussed in a training session.
- Refiners' continuing interest in corrosion will be expressed in a session on this subject.

Here is the tentative program of the mid-year meeting as far as it had been developed by the API at the end of January:

Monday, May 14, Morning

ANALYTICAL RESEARCH

Presiding: G. R. Lake, Union Oil Co. of California. Session was also developed by Mr. Lake.

"Spectrophotometric Determination of Chloride, Bromide, and Iodide," by F. W. Chapman, Jr., and R. M. Sherwood, Atlantic Refining Co.

"Trace Amounts of Total Nitrogen in Petroleum Distillates," by G. R. Bond, Jr., and C. G. Harriz, Houdry Process Corp.

"Trace Amounts of Arsenic in Petroleum Distillates," by N. C. Maranowski, R. E. Snyder, and R. O. Clark, Gulf Research and Development Co.

"X-Ray Absorption Edge Spectroscopy as an Analytical Tool. The Determination of Molybdenum and Zinc," by R. E. Barieau, California Research Corp.

"Trace Quantities of Lead in Gasolines and Naphthas," by Margaret E. Griffing, L. A. Snyder, S. R. Henderson, and Adele Rozek, Ethyl Corp.

"Determination of Water in Methane and Ethanethiol," by G. Matsuyama, Union Oil Co. of California.

"Traces of Carbon Monoxide in Hydrocarbons," by K. H. Nelson, M. D. Grimes, and B. J. Heinrich, Phillips Petroleum Co.

CORROSION

Presiding: G. L. MacPherson, Imperial Oil Ltd. Developed by C. F. Pogacar, Atlantic Refining Co.

"Current Good Painting Practices," by Joseph Bigos, Steel Structures Painting Council, Mellon Institute; and J. O. Jackson, Pittsburgh-Des Moines Steel Co.

"Corrosion Occurring in Crude and Vacuum Distillation Units," by P. D. Thomas, Asiatic Petroleum Co.

"How Richfield Planned to Combat High-Temperature Sulfide Corrosion in Their New Catalytic Reformer," by B. W. Neumaier and C. M. Schillmoller, Richfield Oil Corp.

"High-Temperature Hydrogen Sulfide Corrosion in Commercial Sovaformer Units," by R. D. Drew and E. B. Backensto, Socony Mobil Laboratories; J. N. Vlachos, Socony Mobil Oil Co.

"Effects of Graphitization on the Stress-Rupture Properties of Welded and Unwelded Plain Carbon Steels—A Summary of the Work of the Subgroup on Deterioration of Steels, Subcommittee on Unfired Pressure Vessels, Committee on Refinery Equipment," by J. G. Wilson, Shell Oil Co.

Monday, May 14, Afternoon

ANALYTICAL RESEARCH

Presiding: C. H. Caesar, Imperial Oil Ltd.

"Application of Vapor Phase Chromatography to the Analysis of Liquid Petroleum Fractions," by D. H. Desty and B. H. F. Whyman, British Petroleum Co.

"Quantitative Analysis of Organic Disulfides," by Mrs. R. L. Hubbard, W. E. Haines, and J. S. Ball, United States Bureau of Mines.

"Determination of Fuel Oil Stability by Optical Density Measurements," by W. H. Armstrong, D. Milsom, H. P. Hebert, and A. R. Rescorla, Cities Service Research and Development Co.

"A Rapid, Precise Micro Vapor Pressure Method," by A. Y. Mattlau, Esso Research and Engineering Co.

"Combustion and E.D.T.A. Titrimetric Determination of Total Sulfur in Liquid Petroleum Products," by O. N. Hinsvark and F. J. O'Hara, Girdler Corp.

"Fluorescent X-Ray Spectral Analysis of Powdered Solids by Matrix Dilution," by E. L. Gunn, Humble Oil and Refining Co.

"Direct Versine Titration Methods for Determination of Calcium or Zinc in Lube Oils and Additives," by E. R. Hartmann and P. B. Gearhardt, Esso Research and Engineering Co.

ELECTRICAL EQUIPMENT

Presiding: D. L. Campbell, British American Oil Co. Developed by K. N. Thompson, Socony Mobil Oil Co.

"A Refiner's Experience in Using RP-500," by F. C. Somers, Atlantic Refining Co.

"An Engineering Contractor's Reaction to RP-500," by James T. Pringle, Bechtel Corp.

"Problems in Providing Suitable Electrical Equipment for Class 1, Division 2 Areas," by C. R. Olson, Westinghouse Electric Corp., and Earle R. Hoyle, Sinclair Refining Co.

"Differences Between Canadian and American Refinery Electrical Practices," by an author with Imperial Oil Ltd.

Tuesday, May 15, Morning

TRENDS IN INSTRUMENTATION

Presiding: J. K. Jamieson, Imperial Oil Ltd. Developed by G. N. Ehly, Atlantic Refining Co.

"Service of the Instrument Society of America to the Petroleum Industry," by Robert T. Sheen, Milton Roy Co., and president of the ISA.

"Instrumentation of Petroleum Processes," by James G. Kerley, Shell Oil Co.

"Data Reduction," by Albert F. Sperry, Panellit, Inc.

COMPUTERS

Presiding: A. G. Farquharson, McColl Frontenac Oil Co., Ltd. Developed by C. L. Thomas, Sun Oil Co.

"The Use of Computers in Petroleum Refinery Problems," by Jack Sherman, The Texas Co.

"The Design of Heat Exchangers on Automatic Computing Equipment," by A. M. Peiser, M. W. Kellogg Co.

"Computers in Refinery Planning," by Robert G. Donovan and Robert W. Schrage, Esso Standard Oil Co.

"Calculation of the Equilibrium Composition in C_2 Hydrocarbon-Hydrogen Systems," by Edward B. Weinberger and C. W. Montgomery, Gulf Research and Development Co.

"Growth of a Technical Computing Activity," by T. H. Green, Jr., C. M. Jones, Shell Oil Co.

"Solution of Multicomponent Distillation Problems on a Stored Program Computer," by J. S. Bonner, Humble Oil & Refining Co.

Tuesday, May 15, Afternoon

REFINERY MAINTENANCE

Presiding: Gordon R. Henderson, Sun Oil Co. Ltd. Developed by D. R. Johnson, Continental Oil Co.

"Scope and Administration of Preventive Maintenance," by C. C. Carmine, Tide Water Associated Oil Co.

"Development of Cost Yardsticks," by E. S. Bale, Standard of Ohio.

Prepared discussion by E. C. Newton, Atlantic Refining Co.

FUELS AND LUBRICANTS

Presiding: G. Davidson, Shell Oil Co. of Canada. Developed by T. B. Rendel, Shell Oil Co.

"Statistical Approach to Road Performance," by F. D. Buerstetta, Ethyl Corp., and E. E. Sorenson, British American Oil Co.

"The Combustion Chamber Deposit Problem in High Compression Ratio Engines," by M. W. Corzilius, D. R. Diggs, and R. A. Hoffman, du Pont Co.

"Feeding Problems of the Future Engines," by A. E. Cleveland and R. I. Potter, Ford Motor Co.

Tuesday, May 15, Evening

PROCESSES

Presiding: Charles Hay, Royalite Hi-Way, Ltd. Developed by C. L. Thomas, Sun Oil Co.

"Catforming to High Octanes in Canada," by H. R. Grane and J. A. Nevison, Atlantic Refining Co.

"Commercial Two-Stage Fluid Cracking—A New Technique," by J. D. Heldman, F. Kunreuther, J. A. Marshall, C. A. Rehbein, Shell Oil Co.

"Ultraforming to 100 Octane," by W. F. Johnstone, W. J. Montgomery and P. C. White, American Oil Co.

Wednesday, May 16, Morning

SMOKE AND FUMES

Presiding: John W. Newton, Magnolia Petroleum Co. Developed by W. H. Claussen, California Research Corp.

"Review of the Smoke and Fumes Committee Research Program," by L. C. Kemp, Jr., The Texas Co.

"Recent Developments in the Study of the Organic Chemistry of the Atmosphere," by W. E. Scott, E. R. Stephens, and Philip L. Hanst, The Franklin Institute.

Panel discussion: Air Pollution Control Policy. Panelists: E. B. McConnell, Standard Oil of Ohio; H. G. Osborn, Continental Oil Co.; H. W. Ferguson, Humble Oil and

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Refining Co.; and G. S. Dunham, Socony Mobil Oil Co.

Wednesday, May 16, Afternoon

WASTE DISPOSAL

Presiding: John R. Patton, Regent Refining Co. (Canada). Developed by W. F. Meehan, Standard of Indiana.

"Waste Disposal in Retrospect," by W. B. Hart, Broomall, Pa.

"Air Oxidation of Sulfides in Refinery Process Waters and Caustic Solutions," by A. G. Smith, Shell Oil Co.

"Biological Oxidation of Petroleum Phenolic Waste Water," by Alex D. McRae, Alan A. Sheppard, and William K. Ross, Imperial Oil Ltd.

"The Diatometer—A Method for Indicating the Conditions of Aquatic Life," by Ruth Patrick and Matthew H. Hohn, Philadelphia Academy of Natural Sciences.

"Biological Oxidation and Re-use of Refinery Waste Water for Pollution Control and Water Conservation," by Harold F. Elkin.

Wednesday, May 16, Evening

OPEN DINNER SESSION

Presiding: E. B. McConnell, API Vice-President for Refining, and Standard Oil of Ohio. Developed by D. L. Campbell, British American Oil Co.

Opening remarks by E. B. McConnell.

Presentation of the API "Certificate of Appreciation."

Address by Frank M. Porter, President of the API.

Address by Hon. Louis St. Laurent, Prime Minister of Canada (tentative).

Thursday, May 17, Morning

TRAINING

Presiding: W. Harold Rea, Canadian Oil Cos. Developed by R. R. Faller, Ethyl Corp.

"Developing Engineers in the Field of Refinery Technology," by Dwight S. Simmons, Imperial Oil Ltd.

"The Liberal Arts in Executive Development," by J. Roby Kidd, Canadian Association for Adult Education.

"The Line Manager's Role in Supervisory Development," by G. Davidson, Shell Oil Co. of Canada.

Refinery Problems at NACE Corrosion Annual

Petroleum industry corrosion problems will be taken up in seven different symposia and meetings at the Mar. 12-16 conference and corrosion show of the National Association of Corrosion Engineers. The Statler Hotel in New York City is the site of the event.

Two symposia on refinery corrosion will be held. In these, the following papers have been announced:

"Hydrogen Blistering in a Fluid Catalytic Cracking Unit."

"A Refinery Paint Program to Cut Maintenance Costs."

"Electrical Resistivity Technique for Evaluation of Corrosion Inhibitors in Light Hydrocarbons."

"Collection and Correlation of High Temperature Hydrogen Sulfide Corrosion Data."

In addition, papers will cover these topics: naphthenic acid corrosion, hydrogen chloride evolution from crude oils, and tests of corrosion by hydrogen sulfide and hydrogen in operating units.

Chairmen for the refinery corrosion symposia will be R. J. Hafsten, Standard Oil Co. (Ind.), and J. F. Mason, Jr., International Nickel Co.

A special symposium on protective coatings is planned, and three papers on the following subjects will be read: sprayed metals plus plastic coatings; performance of galvanized coatings sponsored by the American Zinc Institute; and a paper titled "Work Measurement as Applied to Industrial Painting."

Chairmen of this symposium are to be W. P. Cathcart, Tank Lining Corp., and L. S. Van Delinder, Carbide and Carbon Chemicals Corp.

A symposium on chemical inhibition will feature these papers:

"Electrical Resistance Corrosion Measurements Employing Alternating Currents."

"Inhibiting Corrosion of Steel, Aluminum and Magnesium Intermittently Exposed to Brines."

"Laboratory Evaluation of Corrosion Inhibitors.

Chairmen will be J. L. Wasco, Dow Chemical Co., and George E. Best, Mutual Chemical Division, Allied Chemical and Dye Corp.

Persons attending the general corrosion round table will have the opportunity to present questions on any corrosion subject. This session is to be informal, with the audience participating in answering questions from the floor or which have been submitted by mail.

Chairmen for the round table are F. N. Alquist, Dow Chemical Co., and A. H. Roebuck, Continental Oil Co.

Meetings of more than 67 NACE technical committees are scheduled during the week of the conference, and the corrosion show will be held concurrently. The show will feature exhibits of latest equipment and techniques for control and prevention of corrosion.

Statistical Quality Control Short Course at U. of Ill.

A short course in quality control by statistical methods will be offered at the University of Illinois from Mar. 19 to 29. The course consists of 57 hours of instruction by lecture, demonstration, and laboratory or calculation periods. Intensive work will be given in the fields of control charts and acceptance sampling, with some attention paid to the rational setting of specifications and tolerances.

In addition, there will be some

work on the problems of sampling from flow and batch processes.

Purpose of the course is to present mathematical models which can aid making decisions on measurable or observable characteristics of the product. Though primarily for process or product control, these techniques are also successful in inventory control, clerical operations, standards setting, instrument evaluation, and other applications.

Instruction will be under the direction of Prof. John A. Henry, of the university's mechanical engineering laboratory. Instructors are Professors N. H. Barnard, University of Nebraska; I. W. Burr, Purdue; L. A. Knowler, Iowa State; G. W. McElrath, University of Minnesota; I. L. Reis, University of Illinois; and G. F. Schrader, also of Illinois.

3rd Annual Meeting of ACS-AIChE Groups Mar. 9

The third annual joint meeting of the Sabine Area Section, American Institute of Chemical Engineers, and the Texas-Louisiana Gulf Section, American Chemical Society, will be held March 9. The Lamar State College of Technology, Beaumont, Texas, will be host.

A technical session will be held in the morning and a symposium in the afternoon. Papers of special interest to petroleum refiners are as follows:

"Determination of Fluid Catalyst Attrition by Radioactive Tracers," by A. J. Kinsella, The Texas Co.

"The Rotating Disc Contactor," by R. L. Maycock, Shell Chemical Co.

"Corrosion and Metallurgical Factors in the Failure of Process Equipment," by Paul Dillon, Carbide and Carbon Chemicals Co.

"Modern Fuels and Engines," by M. R. Morrow, Humble Oil & Refining Co.

"Solar Batteries," by M. V. Sullivan, Bell Laboratories.

"Gas Turbine Applications in the Petroleum and Chemical Industries," by C. R. Dygert, General Electric Co.

Tentative Program of NGAA Annual Apr. 11-13

The Natural Gasoline Association of America will hold its annual convention April 11 to 13 at Ft. Worth, Texas. A tentative outline of the program has been released. Six forums will be held during the first two days. On Wednesday, April 11, the forums will be on the following:

1. Absorption, computers, and "K" values (three papers on each topic and a demonstration of computer problems).

2. Panel discussion on "Management Considerations in Building Gasoline Plants."

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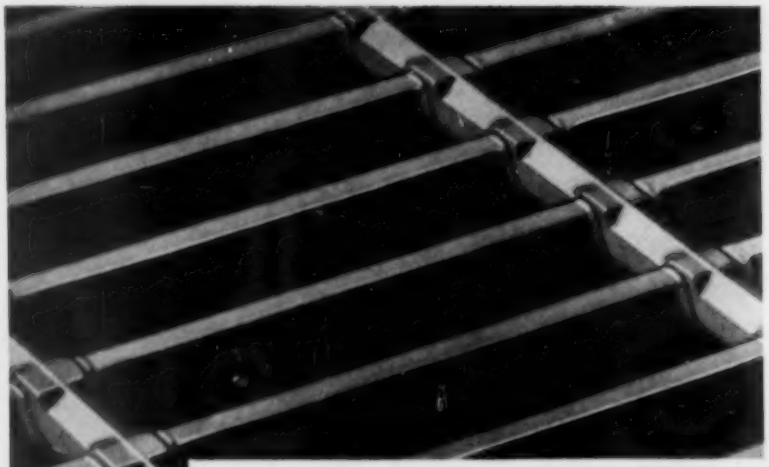

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3. Midget gasoline plants.

These forums will run concurrently. The forums on Thursday morning are on:

1. Corrosion in gasoline plants.
2. Analytical methods and new apparatus.
3. Motor fuels and engines.

Thursday afternoon will be devoted to general sessions and presentation of the Hanlon Award. Addresses will be given by D. A. Hulcy, president of Lone Star Gas Co., Dallas, and Lloyd Minter, director of public relations for Phillips Petroleum Co.

On Friday morning, April 13, there will be general sessions and addresses by John Suman, retired vice-president of Standard Oil Co. (N. J.) and Robert R. Frederick, Ford Motor Co.

First Details of NPA Apr. 18-20 Meeting

Extending the octane scale and the performance of boron gasoline in cars and trucks are two topics to be considered in the technical session of the National Petroleum Association's semi-annual meeting April 18 to 20. The event will be held at the Cleveland Hotel, Cleveland, Ohio.

This session will take place in the morning of April 20 and will consist of these papers:

"Results of the Use of Boron Gasoline in Passenger Cars and Trucks," possibly given by E. C. Hughes, Standard Oil Co. (Ohio).

"Consideration of a Practical Extension to the Octane Scale," by Warren Wiese, General Motors Corp.

"Performance of Gasolines in 1956 Cars," by Messrs. Finnigan and Percy, Pure Oil Co.

In addition, the meeting will have a session on industrial relations as it exists in the oil industry, and a session on lube oils. In the latter, Paul Zumbrook, Sinclair Refining Co., will offer statistics on the production and sales of lube oils. The NPA will also distribute its latest revised listing of lube oil plants in the U. S.

AIChE Section to Meet

The Philadelphia-Wilmington Section of the American Institute of Chemical Engineers will discuss "Economic Practices in the Chemical and Petroleum Industries" at the University of Pennsylvania on April 17.

Oil Man's Calendar

MARCH

Chemical Institute of Canada, 6th divisional conference, Guildwood Inn, Sarnia, Ont., Mar. 5-7.

National Assn. of Corrosion Engineers, cor-

(To obtain more data on advertised products see page 182)

why not fly to the API?

Petroleum Processing in cooperation with Trans Canada Airlines, is sponsoring several flights to the API Refinery Division Convention in Montreal on Sunday, May 13, 1956

TCA flights in the new Vickers Viscount propeller-turbine originate in New York, Cleveland and Chicago. Connections can be arranged with cooperating airlines at these points. All fligbs involved are regularly scheduled flights.

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EMPLOYMENT PROBLEM?

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Meetings

rosion conference and show, Hotel Statler, New York, Mar. 12-16.

Western Petroleum Refiners Assn., annual, Plaza Hotel, San Antonio, Mar. 19-21.

Statistical Quality Control Short Course, University of Illinois, Urbana, Mar. 19-29.

APRIL

American Institute of Electrical Engineers, southwest district No. 7, Dallas, Apr. 2-4.

Corrosion Control Short Course, central Oklahoma section of NACE and University of Oklahoma, University Extension Study Center, Norman, Apr. 3-5.

American Society of Lubrication Engineers, annual, William Penn Hotel, Pittsburgh, Apr. 4-6.

American Chemical Society, national meeting, Dallas, Apr. 8-11.

Natural Gasoline Assn. of America, annual, Texas Hotel, Ft. Worth, Apr. 11-13.

"Economic Practices in the Chemical and Petroleum Industries," Philadelphia-Wilmington Chapter, American Institute of Chemical Engineers, at University of Pennsylvania, Apr. 17.

Southwestern Gas Measurement Short Course, University of Oklahoma, Norman, Apr. 17-19.

National Petroleum Assn., semi-annual, Hotel Cleveland, Cleveland, Apr. 18-20.

World-Oil Exposition, Houston, Apr. 25-29.

American Institute of Electrical Engineers, 2nd Conference on Recording and Controlling Instruments, Bradford Hotel, Boston, Apr. 26-27.

American Petroleum Institute, Safety and Fire Protection Committee, mid-year meeting, Warwick Hotel, Philadelphia, Apr. 30-May 4.

MAY

American Institute of Electrical Engineers, northwestern district, Rochester, N. Y., May 2-4.

Liquefied Petroleum Gas Assn., convention and trade show, Conrad Hilton Hotel, Chicago, May 6-9.

American Institute of Chemical Engineers, national meeting, Roosevelt Hotel, New Orleans, May 6-9.

American Welding Society, annual show, Memorial Auditorium, Buffalo, N. Y., May 9-11.

American Petroleum Institute, Refining Division mid-year meeting, Sheraton-Mt. Royal Hotel, Montreal, May 14-17.

11th Purdue Industrial Waste Conference, Purdue University, Lafayette, Ind., May 15-17.

4th Conference on Mass Spectrometry, ASTM Committee E-14, Netherlands Plaza Hotel, Cincinnati, May 27-June 2.

Chemical Institute of Canada, annual, Mt. Royal Hotel, Montreal, May 28-30.

JUNE

Society of Automotive Engineers, summer, Chalfonte-Haddon Hall, Atlantic City, June 3-8.

National Fire Protection Assn., annual, Statler Hotel, Boston, June 4-8.

American Society of Mechanical Engineers, semi-annual, Statler Hotel, Cleveland, June 17-21.

American Society for Testing Materials, annual, with apparatus exhibit, Chalfonte-Haddon Hall, Atlantic City, June 17-22.

Western Petroleum Refiners Assn., regional technical-industrial relations, Broadview Hotel, Wichita, Kan., June 21-22.

American Institute of Electrical Engineers, summer and Pacific general meetings, San Francisco, June 25-29.

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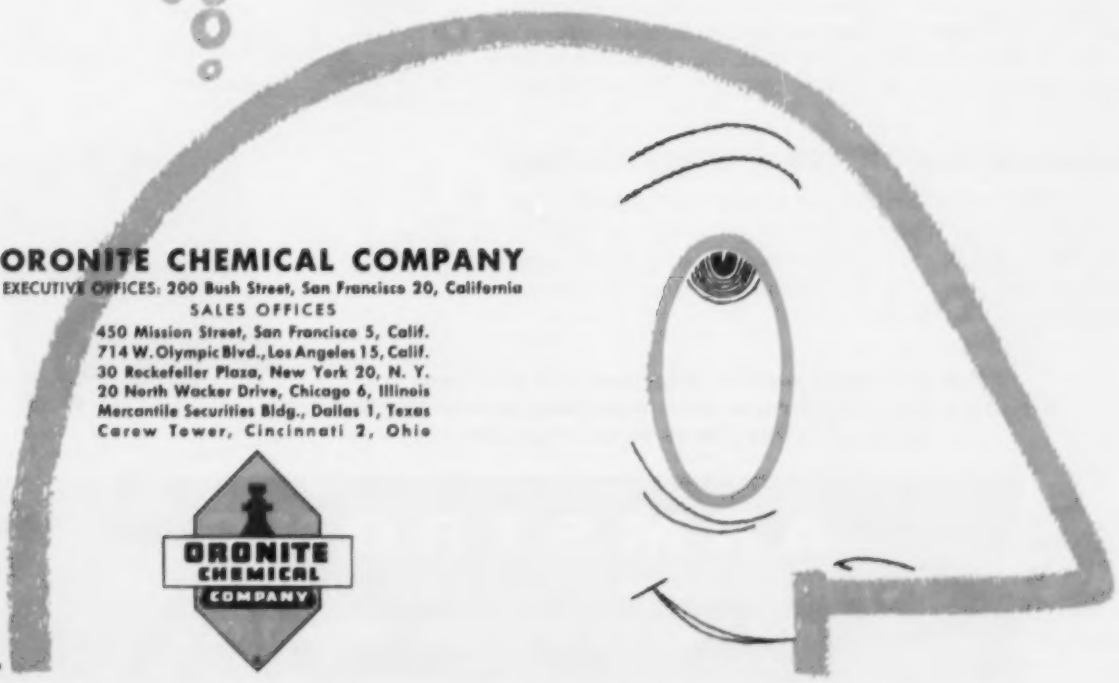

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Dual gravity trap selection and installation explained and diagramed... for draining gasoline separators, dehydrator tanks, debutanizers, etc.... orifice capacity data, dimensions, materials, list prices for Armstrong Ball Float D/G Traps. ASK FOR BULLETIN 2091.

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Catalysis in Hydrogenation And Dehydrogenation

Catalysis, Vol. 3, edited by Paul H. Emmett, 1955, 9¼ x 6½ in., 504 pages, indexed, illustrated, stiff cloth cover, Reinhold Publishing Corp., 430 Park Ave., New York 22 N.Y.

VOLUME 3 consists of contributions by 16 eminent international scientific investigators covering 10 chapters dealing with parahydrogen and orthodeuterium conversions and hydrogen deuterium exchange; catalytic hydrogenation of ethylene; catalytic hydrogenation of olefinic hydrocarbons; addition of hydrogen to carbon-carbon triple bonds; catalytic hydrogenation of nitro compounds; catalytic synthesis of ammonia; recent research on ammonia synthesis; synthesis of methanol; hydrogenation of glyceride oils; catalytic dehydrogenation.

In addition this volume makes available a large amount of practical information and experimental detail about the preparation and the efficient use of various hydrogenation catalysts.

B. M. W. Trapnell of The University of Liverpool, England, presents a basic study of homogeneous catalysis of conversion and exchange; heterogeneous catalysis of conversion and exchange dealing specifically with the hydrogen atom, paramagnetic substances, diamagnetics, magnetic conversion, temperature coefficient, chemical mechanism; conversion and exchange at metal surfaces and chemical conversion by oxide surfaces; poisoning of the conversion; use of the conversion in catalytic problems.

D. D. Eley of the University of Nottingham, England, deals with work explaining the mechanism of hydrogen addition to ethylene emphasizing studies on kinetics; kinetics of hydrogenation; ethylene on nickel and other metals; deuterogenation; stereochemistry of hydrogenation; adsorbed films; preadsorbed ethylene and gaseous hydrogen; reaction of olefin with chemisorbed hydrogen; theory of the absorbed film; parahydrogen conversion; effect on olefin on the parahydrogen conversion; half-hydrogenated state; energy balance.

B. B. Corson of the Mellon Institute of Industrial Research, covers a basic study of selective hydrogenation of olefin treating, mechanism of selective hydrogenation, selective hydrogenation of certain tri- and tetra-substituted ethylenes, selective hydrogenation of mixed ethylenic-aromatic unsaturation, selective hydrogenation of conjugated unsaturation, hydrogenation at superatmospheric pressure and elevated temperature over nickel catalyst, and hydrogenation at atmospheric and room temperature; reduction of olefinic hydrocarbons by calcium-ammonium and alkali metals; hydrogenation of olefins by hydrogen transfer; stereochemistry of hydrogenation of olefins.

G. C. Bond of Leeds University, England, presents a thorough review of theoretical and experimental studies of hydrogen addition to carbon-carbon triple bonds explaining structure and thermochemistry of the acetylenic bond; hydrogenation of acetylenic bonds; gas phase hydrogenation of acetylenic bonds, discussing hydrogenation of acetylene involving various metal catalysts, metallic films, reaction mechanisms and catalytic activity; liquid phase hydrogenation of acetylenic bonds, selective action of catalysts, stereochemical course of reaction.

Hilton A. Smith and William C. Bedoit, Jr., cover a systematic study of aliphatic nitro compounds; aromatic compounds, dealing specifically with nitro alcohols, nitroketones, nitrovinyl polymers, unconjugated nitroolefins, kinetics of hydrocarbons of nitro compounds; experimental results are reported on various nitro compounds using platinum and nickel catalysts.

W. G. Frankenburg covers catalytic ammonia synthesis systematically by tracing early developments in ammonia synthesis leading stepwise to current developments and various methods in use in the manufacture of synthetic ammonia; a large part is devoted to variables of industrial synthesis, technical catalysis, theory of ammonia synthesis, mechanism of activity, and requisites for ammonia catalysts; experimental studies concerning the theory of ammonia synthesis are also included, dealing with measurements of the surface areas of catalysts, state of chemisorbed nitrogen, association of hydrogen with ammonia catalysts, ammonia chemisorption on catalysts, nonuniform character of the chemisorbed phase and its impact on the catalytic process, individual ammonia catalysts, kinetics of catalytic synthesis and decomposition of ammonia in static and flow systems.

C. Bokoven and co-workers of The Netherlands, report the results of investigational work since 1940, dealing with the structure and texture of the catalyst and with chemisorption in ammonia synthesis. Their painstaking studies are carried out in adsorption on heterogenous surfaces, heat of adsorption, rates of adsorption and desorption, adsorption on homogenous surfaces, thermo-ionic function, and experimental data for testing various principles developed by investigators of ammonia synthesis and decomposition at various pressures and temperatures.

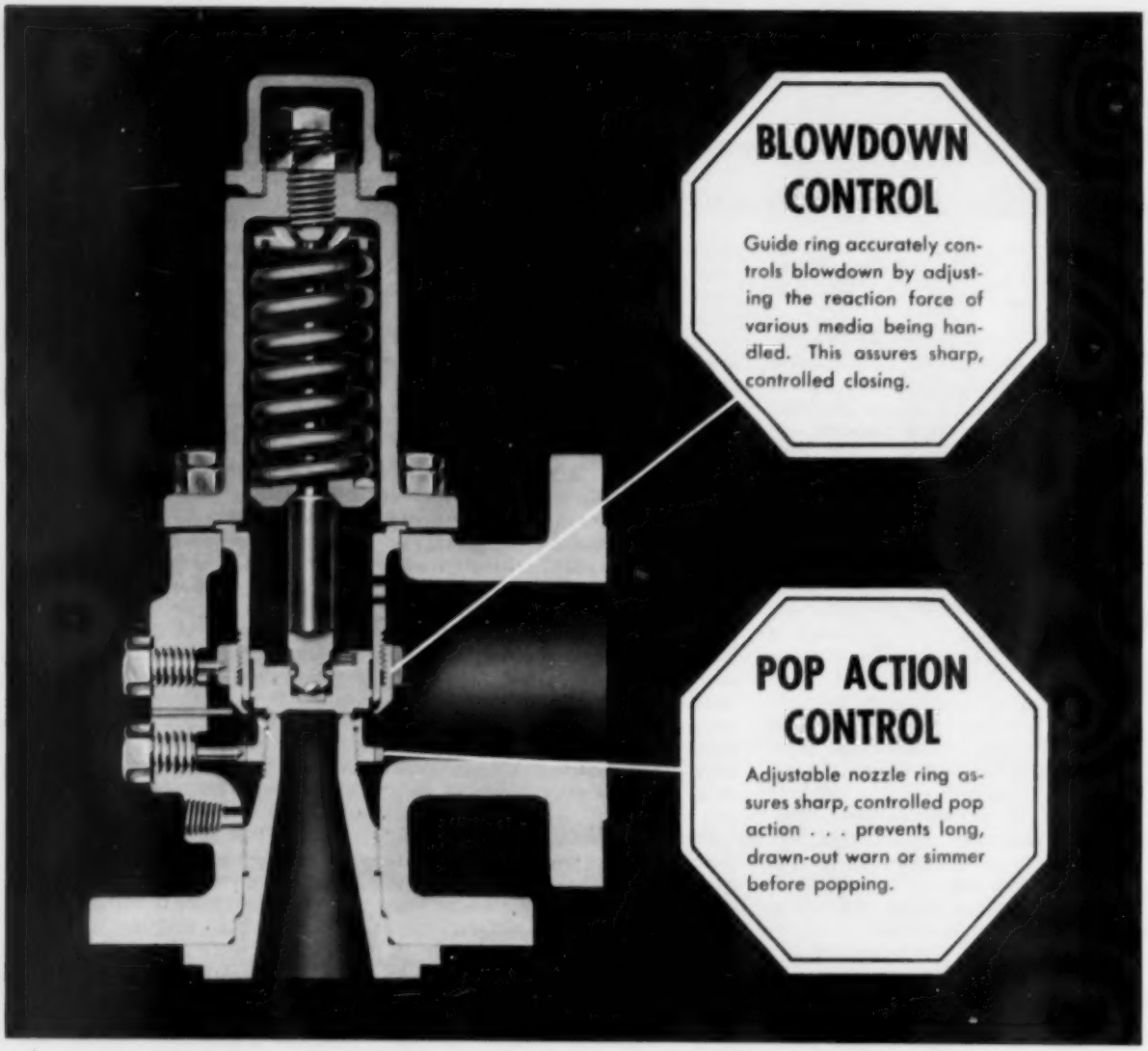
G. Natta of the Polytechnic of Milan, Italy, treats the synthesis of methanol by a study and review of laboratory and large scale developments in the field of catalysis in the synthesis of methanol, with special emphasis on the study of catalysts, namely, methods of preparation and activities, crystal size, mixed catalysts, promoters and effect of concentration, antiselectivity agents and poisons, reaction rates, kinetics, and effects of pressure, gas composition and inert gases and temperature and space velocity and activation heat and mechanism of the synthesis of methanol.

R. O. Feuge presents the investigative and development work on catalytic hydrogenation of glyceride oils for the manufacture of margarine oils and shortenings covering laboratory experiments and large scale operations, dealing with types of catalysts and methods of preparation, namely, supported and unsupported types of catalysts; characteristics of various catalysts; behavior of the components of an oil during hydrogenation and certain other factors influencing hydrogenation.

K. K. Kearby covers catalytic dehydrogenation including several manufacturing processes currently operating and the catalysts involved, with special emphasis on dehydrogenation of paraffins, olefins and alkyl-aryl hydrocarbons; treating in detail equilibrium considerations in paraffin dehydrogenation, effective catalysts, effect of feed diluent on dehydrogenation, thermodynamic equilibria for diolefins and styrenes, best catalysts for producing butadiene, diluents and additives.

The editor, Paul H. Emmett, in addition to his own very valuable contribution, demonstrated unusual skill handling and arranging the material in this book.

Reviewed by David Rothbard
New York City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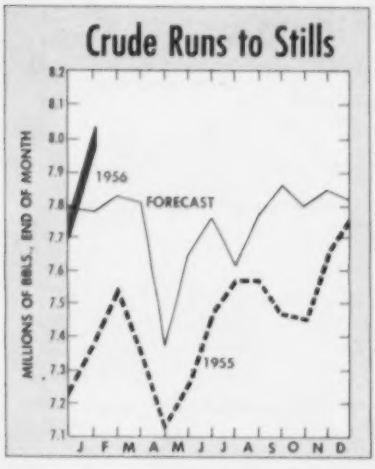
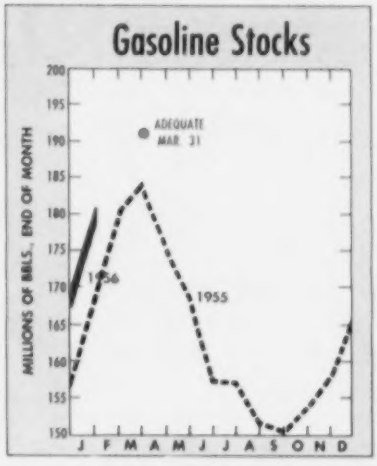
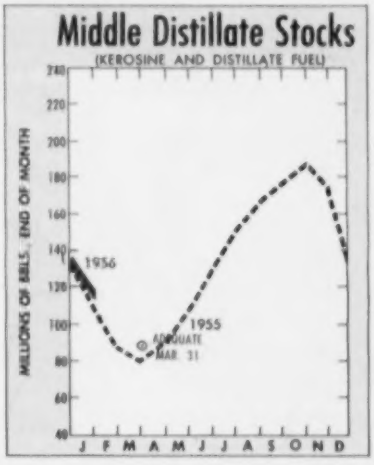






1956 Figures to Jan. 27

High Runs Piling Up Gasoline Stocks

OUTLOOK: For distillate fuels and kerosine stocks combined to end the seasonal drop a little above the low of last year, which was 80,644,000 bbls. on March 31.

WHILE some estimates of 1956 demand are now shading the earlier forecasts, refinery operations continue at a higher rate than seems to be warranted. Continuing high gasoline demand is the chief stimulus to the current rate of operations.

Indicated crude runs to stills in January were 7,993,00 b/d avg., over 8% higher than in January, 1955, and over 2% higher than the Bureau of Mines forecast of crude charges for the current period. The Bureau estimates 7,830,000 b/d avg. crude runs in February as in line with supplying demand conditions.

Gasoline consumption holds up at a higher rate than had been anticipated. Indicated demand at refineries in January was 3,435,000 b/d avg., 7.6% higher than actual demand for January, 1955. The BM revised forecast of gasoline demand for the first quarter, 3,460,00 b/d avg., is about 6% higher than actual demand for the first quarter of 1955.

Even with the continuing strong motor fuel demand, gasoline inventories at refineries are building up at a rate that could bring total U. S. stocks March 31 to 195,000,000 bbls. This would be 11,000,000 bbls. higher than the same date in 1955, and a possible psychological factor in the spring gasoline market.

Severe cold in January in the areas of largest heating oil consumption, pulled U. S. middle distillate inventories (kerosine and distillate fuel oils combined) to a few million barrels under those of January, 1955. More moderate weather in early February appeared to be slowing down the high rate of demand in January. The Bureau of Mines revised forecast of first quarter demand for middle distillates is 8% larger than the same period in 1955.

With the continuing high rate of refinery operations, inventories of middle distillates March 31 will likely be above at the 1955 level—80,644,000 bbls.

JANUARY KEY STATISTICS

(Figures given in terms of millions of b/d, monthly averages, except stocks, which are in millions of bbls. at end of month)

	Jan. 1956*	Dec. 1955	Jan. 1955
CRUDE OIL			
U. S. Production	7.019	6.956	6.761
Imports	.751	.865	.740
U. S. Stocks	258.406	262.033	260.156
Runs to Stills	7.993	7.764	7.379
GASOLINE			
Refinery Output	3.821	3.854	3.557
Refinery Demand	3.435	3.694	3.192
Primary Stocks	178.947	165.803	169.562
MIDDLE DISTILLATES			
Refinery Output	2.292	2.134	2.149
Refinery Demand	3.349	3.291	3.001
Primary Stocks	110.753	139.284	109.958
RESIDUALS			
Refinery Output	1.295	1.263	1.235
Imports	.489	.552	.573
Total Supply	1.784	1.815	1.808
Refinery Demand	1.839	1.962	1.908
Primary Stocks	38.351	39.850	40.457

*Through Jan. 27.

PRODUCT AND CRUDE PRICES

(Products—¢ gal., weighted average prices in principal refinery markets
Crudes—$/bbl., principal fields
Source—Platt's Oilgram Price Service)

	Jan. 1956*	Dec. 1955	Jan. 1955
Gasoline (regular)	11.81	11.81	11.28
Distillate Fuel Oil	9.45	9.11	9.22
Kerosine	10.85	10.51	10.69
Residuals	5.09	4.96	4.18
Above 4 Products	9.39	9.29	8.81
Lube Oils	21.03	20.44	16.48
Crude	2.83	2.83	2.81

REFINERY YIELDS

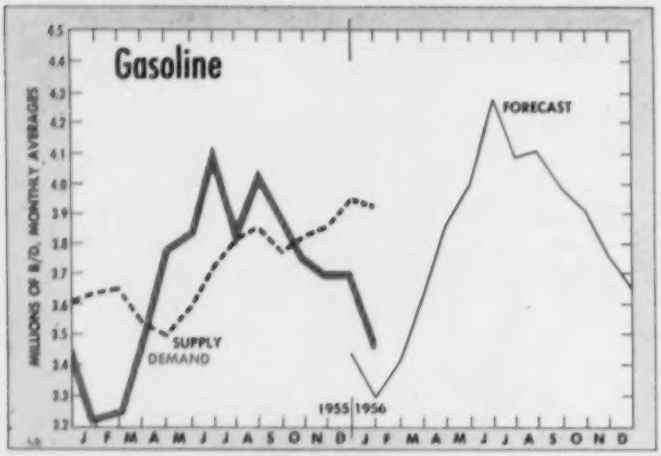
% on Crude Runs to Stills

	Jan. 1956*	Dec. 1955	Jan. 1955
Gasoline	43.6	45.4	42.9
Kerosine	4.6	4.6	5.5
Distillate	24.1	22.8	23.2
Residuals	16.2	16.3	21.1

*Through Jan. 27.

SOURCE OF DATA (except prices): Nov., Dec. and Jan., API weekly reports; earlier months, Bureau of Mines

Gasoline Demand Continues at High Level

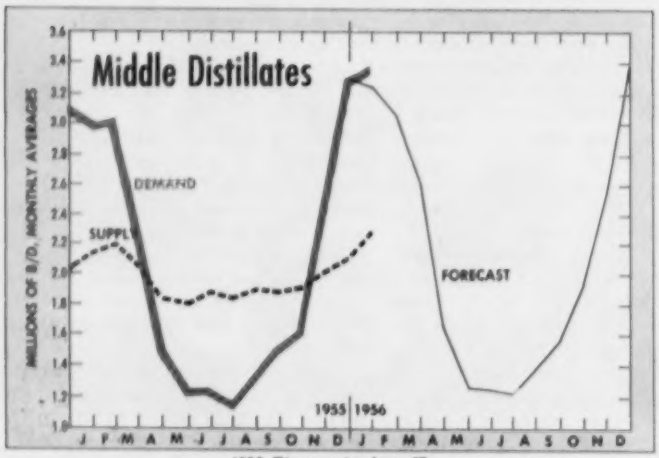


1956 Figures to Jan. 27

MOTOR FUELS

	From Crude	From Nat. Gas	Total
SUPPLY (Millions of b/d)			
Jan. '56	3.481	.440	3.921
Jan. '55	3.207	.432	3.639
Change	+ .274	+ .008	+ .282
% Change	+ 8.5	+ 1.9	+ 7.7
DEMAND (including Exports) (Millions of b/d)			
Jan. '56			3.435
Jan. '55			3.192
Change			+ .243
% Change			+ 7.6
TOTAL SUPPLY (Millions of bbls.)			
12 Mos. '55	1,206.565	155.592	1,362.157
12 Mos. '54	1,115.440	153.712	1,269.152
Change	+91.125	+ 1.880	+ 93.005
% Change	+ 8.2	+ 1.2	+ 7.3
TOTAL DEMAND (including Exports) (Millions of bbls).			
12 Mos. '55			1,355.306
12 Mos. '54			1,272.809
Change			+ 82.497
% Change			+ 6.5

Continued Cold Keeps Distillate Shipments High

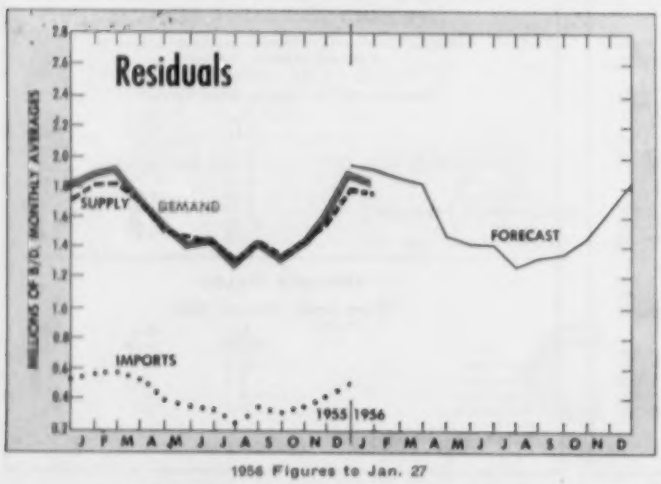


1956 Figures to Jan. 27

MIDDLE DISTILLATES

	Kerosine	Dist. Fuel Oil	Total
PRODUCTION (Millions of b/d)			
Jan. '56	.366	1.926	2.292
Jan. '55	.409	1.740	2.149
Change	—.043	+ .186	+ .143
% Change	—10.5	+ 10.7	+ 6.7
DEMAND (including Exports) (Millions of b/d)			
Jan. '56	.577	2.772	3.349
Jan. '55	.556	2.445	3.001
Change	+ .021	+ .327	+ .348
% Change	+ 3.8	+ 13.4	+ 11.6
TOTAL PRODUCTION (Millions of bbls.)			
12 Mos. '55	117.837	602.259	720.096
12 Mos. '54	122.306	542.278	664.583
Change	— 4.468	+ 59.981	+ 55.513
% Change	— 3.7	+ 11.1	+ 8.3
TOTAL DEMAND (including Exports) (Millions of bbls).			
12 Mos. '55	118.278	604.746	723.024
12 Mos. '54	123.163	550.570	673.733
Change	— 4.885	+ 54.176	+ 49.291
% Change	— 3.9	+ 9.9	+ 7.3

Residual Fuel Oil Supply Drops a Little



1956 Figures to Jan. 27

RESIDUAL FUELS

	Refinery Output	Imports	Total
SUPPLY (Millions of b/d)			
Jan. '56	1.299	.510	1.809
Jan. '55	1.235	.573	1.808
Change	+ .064	— .063	+ .001
% Change	+ 5.2	— 11.0	.0
DEMAND (including Exports) (Millions of b/d)			
Jan. '56			1.839
Jan. '55			1.908
Change			— .069
% Change			— 3.6
TOTAL SUPPLY (Millions of bbls.)			
12 Mos. '55	418.440	149.660	568.100
12 Mos. '54	416.757	129.009	545.766
Change	+ 1.683	+ 20.651	+ 22.334
% Change	+ 0.4	+ 16.0	+ 4.1
TOTAL DEMAND (including Exports) (Millions of bbls).			
12 Mos. '55			584.058
12 Mos. '54			548.955
Change			+ 35.103
% Change			+ 6.4

SOURCE OF DATA: Nov., Dec. and Jan., API weekly reports; earlier months, Bureau of Mines

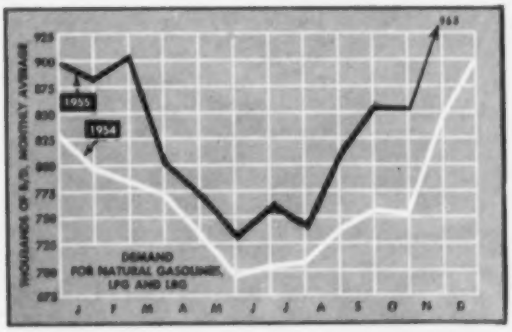
RUNS TO STILLS AND DISTRIBUTION OF PRIMARY STOCKS BY U. S. REFINERY DISTRICTS

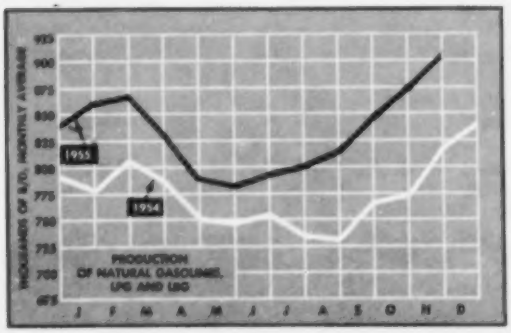
(Primary stocks include those at refineries, at large terminals and in pipelines; all data based on API reports)

District	RUNS TO STILLS (Millions of b/d average for week ending on date shown) Jan. 27 1956	Jan. 28 1955	Change	% Change	GASOLINE STOCKS (Millions of bbls., on date shown) Jan. 27 1956	Jan. 28 1955	Change	% Change	RESIDUAL STOCKS (Millions of bbls., on date shown) Jan. 27 1956	Jan. 28 1955	Change	% Change
East Coast	1.158	1.143	+ .015	+ 1.3	35.892	34.209	+ 1.683	+ 4.9	10.646	8.842	+ 1.804	+20.4
Gulf Coast	2.578	2.409	+ .169	+ 7.0	36.523	35.596	+ .927	+ 2.6	7.971	5.496	+ 2.475	+45.0
Total Coastal	3.736	3.552	+ .184	+ 5.2	72.415	69.805	+ 2.610	+ 3.7	18.617	14.338	+ 4.279	+29.9
Appalachian	.210	.198	+ .012	+ 6.1	7.258	7.104	+ .154	+ 2.2	.790	.683	+ .107	+15.7
Ind.-Ill.-Ky.	1.516	1.358	+ .158	+11.6	36.731	37.768	— 1.037	— 2.7	4.048	3.332	+ .716	+21.5
Okla.-Kans.-Mo.	.759	.679	+ .080	+11.8	20.527	17.283	+ 3.244	+18.8	1.022	1.199	— .177	—14.8
Other Inland	.664	.624	+ .040	+ 6.4	17.850	17.710	+ .140	+ 0.8	2.206	2.375	— .169	— 7.1
Total Inland	3.149	2.859	+ .290	+10.1	82.366	79.865	+ 2.501	+ 3.1	8.066	7.589	+ .477	+ 6.3
Total East of Calif.	6.885	6.411	+ .474	+ 7.4	154.781	149.670	+ 5.111	+ 3.4	26.683	21.927	+ 4.756	+21.7
Calif.	1.172	.991	+ .181	+18.3	24.166	19.942	+ 4.224	+21.2	11.668	26.610	—14.942	—56.2
Total U. S.	8.057	7.402	+ .655	+ 8.8	178.947	160.612	+ 9.335	+ 5.5	38.351	48.537	—10.186	—21.0

District	DISTILLATE FUEL OIL STOCKS (Millions of bbls., on date shown) Jan. 27 1956	Jan. 28 1955	Change	% Change	KEROSINE STOCKS (Millions of bbls., on date shown) Jan. 27 1956	Jan. 28 1955	Change	% Change	TOTAL MIDDLE DISTILLATE STOCKS (Millions of bbls., on date shown) Jan. 27 1956	Jan. 28 1955	Change	% Change
East Coast	30.830	32.077	— 1.247	— 3.9	8.929	9.850	— .921	— 9.4	39.759	41.927	— 2.168	— 5.2
Gulf Coast	14.545	12.651	+ 1.894	+15.0	3.874	4.125	— .251	— 6.1	18.419	16.776	+ 1.643	+ 9.8
Total Coastal	45.375	44.728	+ .647	+ 1.4	12.803	13.975	— 1.172	— 8.4	58.178	58.703	— .525	— 0.9
Appalachian	2.386	2.613	— .227	— 8.7	.871	.935	— .064	— 6.8	3.257	3.548	— .291	— 8.2
Ind.-Ill.-Ky.	15.644	16.407	— .763	— 4.6	5.018	6.618	— 1.600	—24.2	20.662	23.025	— 2.363	—10.3
Okla.-Kans.-Mo.	9.339	9.791	— .452	— 4.6	.978	1.494	— .516	—34.5	10.317	11.285	— .968	— 8.6
Other Inland	5.798	4.955	+ .843	+17.0	1.614	1.114	+ .500	+44.9	7.412	6.069	+ 1.343	+22.1
Total Inland	33.167	33.766	— .599	— 1.8	8.481	10.161	— 1.680	—16.5	41.643	43.927	— 2.279	— 5.2
Total East of Calif.	78.542	78.494	+ .048	—	21.284	24.136	— 2.852	—11.8	99.826	102.630	— 2.804	— 2.7
California	10.619	10.538	+ .081	+ 0.8	.308	.396	— .088	—22.2	10.927	10.934	— .007	—
Total U. S.	89.161	89.032	+ .129	+ 0.1	21.592	24.532	— 2.940	—12.0	110.753	113.564	— 2.811	— 2.5

Natural Gas and Refinery Gas Liquids





SUPPLY AND DEMAND STATISTICS
(Bureau of Mines Data)

CURRENT PRODUCTION

(1000 b/d monthly average)	Nov. 1955	Oct. 1955	Nov. 1954
At Natural Gasoline and Cycling Plants			
Liquefied Petroleum Gas	419	381	360
Natural Gasoline and Isopentane	281	283	274
Condensate	24	21	23
Finished Gasoline, Naphtha and other	63	62	65
Total Natural Gasoline and Cycling Plant Production	787	747	722
Liquefied Refinery Gases	122	129	97
Total Marketable Gas Liquids	909	876	819
Lease Condensate	118	114	102
Total Natural Gas Liquids	1,027	990	921

CURRENT DEMAND (1000 b/d monthly average)

LPG and LRG	591	491	473
Natural Gasoline, Isopentane and Other	377	365	373
Total Marketable Gas Liquids	968	856	846

CUMULATIVE PRODUCTION (1000 bbls.)	Nov. 1955	Nov. 1954
LPG and LRG	157,832	138,291
Natural Gasoline, Isopentane and Other	120,888	117,977
Total Marketable Gas Liquids	278,720	256,268

CUMULATIVE DEMAND (1000 bbls.)

LPG and LRG	154,579	132,981
Natural Gasoline, Isopentane and Other	121,798	118,384
Total Marketable Gas Liquids	276,377	251,365

STOCKS (1000 bbls., end of month)	Nov. 1955	Oct. 1955	1954
LPG and LRG	11,011	12,544	9,787
Natural Gasoline, Isopentane and Other	4,216	4,456	4,481
Total Stocks	15,227	17,000	14,268

Information Offered in the Advertisements

Do you need detailed information on a specific subject? Check through this easy-to-use index of literature and data being offered in this issue's advertisements.

ACETYLENE DERIVATIVES, technical information and samples; Gen'l. Aniline & Film Corp. See adv't. p. 45.

AGITATORS AND MIXERS, bulletin; Patterson Foundry & Machine Co. See adv't. p. 165.

ALUMINA, fused, booklet on refractory grain; Norton Co. See adv't. p. 201.

ALUMINUM, for heat exchangers, booklet; Reynolds Metals Co. See adv't. pp. 54-55.

ANALYZERS, for gas and liquids, bulletin 83; Burrell Corp. See adv't. p. 170.

BARIUM CHEMICALS, for gasoline additives, booklet; Westvaco Mineral Products. See adv't. p. 146.

CATALYSTS, tableted, many kinds, booklet; Harshaw Chemical Co. See adv't. p. 1.

CLEANING COMPOUNDS, for heat exchangers, booklet; Oakite Products, Inc. See adv't. p. 195.

COMPRESSORS, for gas, centrifugal and axial flow, booklet; Carrier Corp. See adv't. p. 211.

ETHANOLAMINES, for gas treating, samples and literature; Nitrogen Div., Allied Chemical. See adv't. p. 132B.

FABRICATION XX of heavy equipment, booklet; Newport News Shipbuilding & Drydock Co. See adv't. p. 197.

FANS, propeller, controllable pitch, for heat exchangers and cooling towers, bulletins A-111 & A-113; Hartzell Propeller Fan Co. See adv't. pp. 100A-100B.

FLOW MEASUREMENT, rotameter, bulletin 115; Brooks Rotameter Co. See adv't. p. 198.

FITTINGS, "Swagelok," catalog; Crawford Fitting Co. See adv't. p. 168.

FLANGES, drop forged, new catalog; Phoenix Mfg. Co. See adv't. p. 218.

FUEL RATING equipment, list available; Ethyl Corp. See adv't. pp. 4-5.

GRADIATION HEATERS, bulletin 93; Selas Corp. of America. See adv't. p. 44.

GRATING, stainless steel, welded, catalog PP-36; Standard Steel Spring Div. See adv't. p. 170.

HEAT EXCHANGERS, floating head construction, bulletin HE-6; Henry Vogt Machine Co. See adv't. p. 37.

HEAT EXCHANGERS, information on fabrication facilities; Western Supply Co. See adv't. p. 39.

HEAT EXCHANGERS, design and installation, bulletin MD-164; Lummus Co. See adv't. p. 31.

HEAT EXCHANGERS, evaporative cooling, bulletins 120 & 124; Niagara Blower Co. See adv't. p. 194.

INHIBITOR, protects pipelines against rust and corrosion, samples and information; Universal Oil Products Co. See adv't. p. 100.

INSULATION, for tanks, blanket rolls, samples and specifications; Gustin-Bacon Mfg. Co. See adv't. p. 209.

INSULATION, cellular glass, sample; Pittsburgh Corning Corp. See adv't. p. 148.

INSULATION, high temperature, many shapes and sizes, information; Owens-Corning Fiberglas Corp. See adv't. p. 139.

JACKETED PIPE, for uniform temperature, bulletins F1-49 & J-50; Hetherington & Berner, Inc. See adv't. p. 210.

LABORATORY APPARATUS, furnaces, bulletin 1001; Lindberg Engineering Co. See adv't. p. 206.

MATERIALS HANDLING, for long and awkward loads, bulletin 1360; Baker-Raulang Co. See adv't. p. 99.

METALS AND ALLOYS, folder TL56 lists publications available; Cooper Alloy Corp. See adv't. p. 190.

MIXERS, side and top entering, eight catalogs and data sheets; Mixing Equipment Co. See adv't. p. 62.

MOTOR STARTERS, oil immersed, 2300-5000 volts, bulletin 1062-20; Electric Controller & Mfg. Co. See adv't. p. 202.

PACKING, "Teflon," and other materials, catalogs TP-1255 & 4-R-10; U. S. Gasket Belmont Packing. See adv't. p. 208.

PIPE, Saran lined, corrosion resistant, information; Dow Chemical Co. See adv't. p. 34.

POTENTIOMETER TRANSMITTER, electronic-pneumatic, bulletin 98262; Taylor Instrument Cos. See adv't. p. 138.

PUMPS, stuffingboxless, bulletin 107; Bingham Pump Co. See adv't. p. 193.

REFRACTORIES, movie relates the story of the refractories industry; General Refractories Co. See adv't. p. 33.

SCAFFOLDING, prefab, steel frame, bulletins PTS-18, PSS-34 & J-9(M); Patent Scaffolding Co., Inc. See adv't. p. 152.

SEALS, shaft, various types for different services, bulletin; Crane Packing Co. See adv't. p. 216.

SEPARATOR-FILTER, vertical, for removal of water and solids from liquid fuels, bulletin WL-5-56; Warner Lewis Co. See adv't. p. 30.

TANTALUM, corrosion resistant metal, test kit and journal; Fansteel Metallurgical Corp. See adv't. p. 169.

TEMPERATURE TRANSMITTER, pneumatic, bulletin 13-17; Foxboro Co. See adv't. pp. 22-23.

TRAPS, steam, impulse type, bulletin T-1739-X; Yarnall-Waring Co. See adv't. p. 60.

TRAPS, steam, bulletin 10-55; W. H. Nicholson Co. See adv't. p. 215.

TRAPS, steam, selector booklet; V. D. Anderson Co. See adv't. p. 144.

TRAPS, steam, air and liquid venting, bulletins 289, 450, 2091 & catalog J; Armstrong Machine Works. See adv't. p. 174.

TUBES, integral finned, booklet; Wolverine Tube. See adv't. pp. 52A-52B.

TUBES, dual metal, bulletin 1954; Bridgeport Brass Co. See adv't. p. 36.

TUBING, pressure, for heat exchangers, bulletin TB-329-PP; Babcock & Wilcox Co. See adv't. p. 48.

TURBINES, high speed, compressor-drive, bulletin 1966; Worthington Corp. See adv't. pp. 46-47.

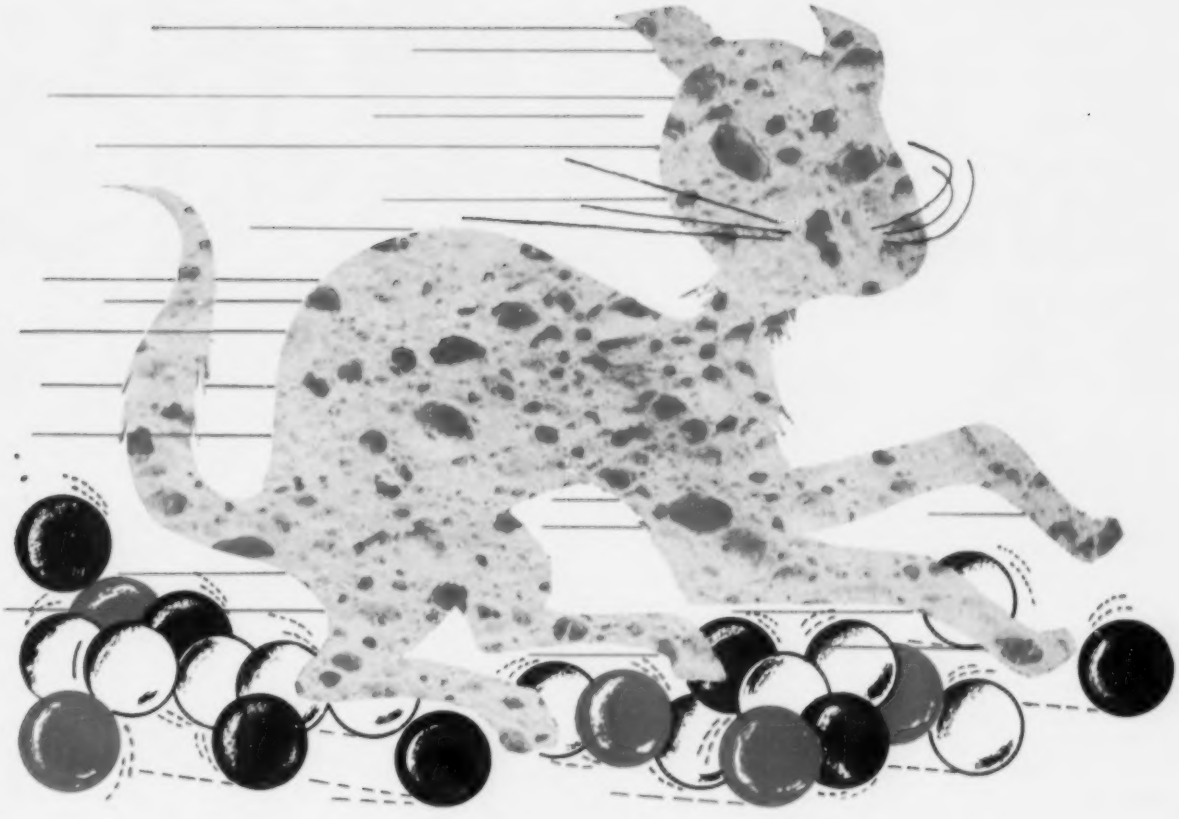
VALVES, pipe line, single and double disc, literature; Crane Co. See adv't. p. 134.

VALVES, safety relief, standard or bellows, catalog 1900; Manning, Maxwell & Moore, Inc. See adv't. p. 20.

VALVES, safety relief, nozzle type, bulletin; Crosby Steam Gage & Valve Co . See adv't. p. 176.

WELDING ELECTRODES, powdered iron, information; Champion Rivet Co. See adv't. p. 157.

WIRE, insulated, for thermocouples and extension leads, bulletin 1200; Claud S. Gordon Co. See adv't. p. 192.



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Each advertiser listed in this index has been assigned a code letter for use by the reader in securing additional information about advertised products, or services which interest him. This code letter appears in parantheses following the advertiser's name.

Circle the code letter on the "Advertised Product Inquiry" card (on the page opposite) which corresponds to that assigned the advertiser about whose product you want further information.

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ADVERTISERS' INDEX

A

Air Preheater Corp. (B-8) 26
Air Products, Inc. (E-2) 49
Airetool Mfg. Co. (N-6) 214
Alloy Steel Products Co., Inc. (F-8) 132A
American Cyanamid Co., Refinery Chem. Dept. (K-5) 181
American Floor Surfacing Machine Co. (J-6) 166
Anderson Co., V. D. (G-7) 144
Annin Co. (N-1) 210
Armstrong Machine Works (K-3) 174

B

Babcock & Wilcox Co. (E-1) 48
Baker-Raulang Co. (F-6) 99
Betz, W. H. & L. D. (F-1) 57
Bingham Pump Co. (L-2) 193
Black, Sivalls & Bryson, Inc. (K-9) 191
Bridgeport Brass Co. (C-9) 36
Brooks Rotameter Co. (L-7) 198
Brown Fintube Co. (E-4) 51
Burrell Corp. (K-1) 170

C

Carrier Corp. (N-3) 211
Champion Rivet Co. (H-7) 157
Chicago Bridge & Iron Co. (H-8) 158
Condenser Service & Engr. Co. (N-4) 212
Cooper Alloy Co. (K-8) 190
Cooper-Bessemer Corp. (B-7) 25
Crane Co. (G-1) 134
Crane Packing Co. (N-8) 216
Crawford Fitting Co. (J-7) 168
Crosby Steam Gage & Valve Co. (K-4) 176

D

Dow Chemical Co. (C-7) 34
Dowell, Inc. (M-3) 203
Downingtown Iron Works, Inc. (L-1) 192
Dresser Industries, Inc. (K-7) 188-189
DuPont de Nemours & Co., Inc. (B-3) 20A-20B
DuPont de Nemours & Co., Inc. (J-3) 162

E

Eastman Chemical Prods., Inc. (J-2) 161
Elect. Controller & Mfg. Co. (M-2) 202
Enjay Co. (C-5) 32
Ernst Water Column & Gage Co. (J-4) 164
Ethyl Corp. (A-3) 4-5

F

Fansteel Metallurgical Corp. (J-8) 169
Farris Engineering Corp. (B-1) 18-19
Fisher Governor Co. (O-4) 220-221
Foster Wheeler Corp. (H-2) 151
Foxboro Co. (B-5) 22-23

G

Gen'l. American Trans. Corp., Plate & Welding Div. (A-4) 6
Gen'l. American Trans. Corp., Terminals Div. (A-5) 8
Gen'l. Aniline & Film Corp. (D-8) 45
Gen'l. Chemical Div., Allied Chem. & Dye Corp. (O-5) Cover 3
General Refractories Co. (C-6) 33
Girdler Corp. (E-3) 50
Gordon Co., Claud S. (G-5) 142
Graver Tank & Mfg. Co. (A-8) 14
Gustin-Bacon Mfg. Co. (M-9) 209

H

Harshaw Chemical Co. (A-2) 1
Hartzell Propeller Fan Co. (O-7) 100A-100B
Hercules Powder Co. (A-6) 11
Hetherington & Berner, Inc. (N-2) 210
Houdry Process Corp. (M-5) 205
Hudson Engineering Corp. (A-1) Cover 2

I

International Nickel Co. (F-4) 61

J

Johns-Manville Corp. (O-3) 219

K

Kellogg Co., M. W. Fabricated Prods. Div. (A-9) 17
Kellogg Co., M. W. Refinery Process Div. (L-8) 199
Key Co. (B-4) 21
Koch Engineering Co. (C-1) 28
Krueger Engr. & Mfg. Co. (J-1) 160

L

Lindberg Engineering Co. (M-6) 206
Lukens Steel Co. (G-6) 143
Lummus Co. (A-7) 13
Lummus Co., Heat Exchanger Div. (C-4) 31

M

Manning, Maxwell & Moore, Inc. (B-2) 20
Maywood Chemical Works (H-9) 160
McKee Co., Arthur G. (B-6) 24
Mixing Equipment Co. (F-5) 62

N

National Airoil Burner Co. (H-4) 154
National Aluminate Corp. (D-4) 40
National U. S. Radiator Co. (H-6) 156
Newport News Shipbuilding & Drydock Co. (L-6) 197
Niagara Blower Co. (L-3) 194
Nicholson & Co., W. H. (N-7) 215
Nitrogen Div., Allied Chem. & Dye Corp. (F-9) 132B
Norton Co. (M-1) 210

O

Oakite Products, Inc. (L-4) 195
Oil Industry Information Comm. (C-2) 29
Olin-Mathieson Chem. Corp. (N-5) 213
Oronite Chemical Co. (K-2) 173
Owens-Corning Fiberglas Corp. (G-3) 139

P

Patent Scaffolding Co., Inc. (H-3) 152
Patterson Foundry & Mach. Co. (J-5) 165
Petreco (E-7) 53
Petro-Chem Development Co., Inc. (G-4) 140
Phelps Dodge Refining Corp. (H-5) 155
Phoenix Mfg. Co. (O-2) 218
Pittsburgh Corning Corp. (H-1) 148
Powell Co., William (K-6) 187
Procon, Inc. (M-7) 207

R

Refinery Engineering Co. (C-8) 35
Reynolds Metals Co. (E-8) 54-55
Rhodia, Inc., Alamask Div. (M-4) 204
Ridge Tool Co. (L-5) 196
Rockwell-Nordstrom Valves (D-5) 41

S

Schuyler Mfg. Co. (D-2) 38
Scovill Mfg. Co. (E-5) 52
Selas Corp. of America (D-7) 44
Shell Oil Co. (D-6) 42-43
Standard Steel Spring Div. (J-9) 170

T

Taylor Instrument Cos. (G-2) 138
Tennessee Corp (L-9) 200

U

U. S. Gasket Co. (M-8) 208
U. S. Steel Corp. (G-8) 145
Universal Oil Products Co. (F-2) 58-59
Universal Oil Products Co., Products Div. (F-7) 100

V

Vogt Machine Co., Henry (D-1) 37

W

Warner Lewis Co. (C-3) 30
Warren Petroleum Corp. (N-9) 217
Washington Aluminum Co., Inc. (O-1) 218
Western Supply Co. (D-3) 39
Westvaco Mineral Products (G-9) 146
Wolverine Tube, Div. Calumet & Hecla, Inc. (E-6) 52A-52B
Worthington Corp. (D-9) 46-47
Wyatt Metal & Boiler Works (O-6) Cover 4

Y

Yarnall-Waring Co. (F-3) 60
York Co., Otto H. (E-9) 56

Z

Zallea Brothers (B-9) 27

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES 172

This index is published as a convenience. Every care is taken to make it accurate, but PETROLEUM PROCESSING assumes no responsibility for errors or omissions.

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21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

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A1	B1	C1	D1	E1	F1	G1	H1	J1	K1	L1	M1	N1	O1	P1	Q1	S1	T1	U1	V1
A2	B2	C2	D2	E2	F2	G2	H2	J2	K2	L2	M2	N2	O2	P2	Q2	S2	T2	U2	V2
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A4	B4	C4	D4	E4	F4	G4	H4	J4	K4	L4	M4	N4	O4	P4	Q4	S4	T4	U4	V4
A5	B5	C5	D5	E5	F5	G5	H5	J5	K5	L5	M5	N5	O5	P5	Q5	S5	T5	U5	V5
A6	B6	C6	D6	E6	F6	G6	H6	J6	K6	L6	M6	N6	O6	P6	Q6	S6	T6	U6	V6
A7	B7	C7	D7	E7	F7	G7	H7	J7	K7	L7	M7	N7	O7	P7	Q7	S7	T7	U7	V7
A8	B8	C8	D8	E8	F8	G8	H8	J8	K8	L8	M8	N8	O8	P8	Q8	S8	T8	U8	V8
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R2	R5	R8	R11	R14	R17	R20	R23	R26	R29	R32	R35	R38	R41	R44	R47
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61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
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A4	B4	C4	D4	E4	F4	G4	H4	J4	K4	L4	M4	N4	O4	P4	Q4	S4	T4	U4	V4
A5	B5	C5	D5	E5	F5	G5	H5	J5	K5	L5	M5	N5	O5	P5	Q5	S5	T5	U5	V5
A6	B6	C6	D6	E6	F6	G6	H6	J6	K6	L6	M6	N6	O6	P6	Q6	S6	T6	U6	V6
A7	B7	C7	D7	E7	F7	G7	H7	J7	K7	L7	M7	N7	O7	P7	Q7	S7	T7	U7	V7
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- **The Heat Exchanger**—covering process and mechanical design, cost estimating factors, types of construction, etc. appearing in this issue. 32 pages—$1.00: Circle **R8**

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- **Catalytic Reforming Survey**—with trends, theory and processes for catalytic reforming and aromatics recovery. 48 pages—$0.75: Circle **R3**

- **Clip•n•File Sheets.** $0.20 each, or any 6 for $1.00. Process Data Sheets (**PDS's**) are 3-page fold-outs with flow diagram, process description, conditions and economics. Engineering Data Sheets (**EDS's**) are two pages on special heavy paper to allow repeated handling and use.

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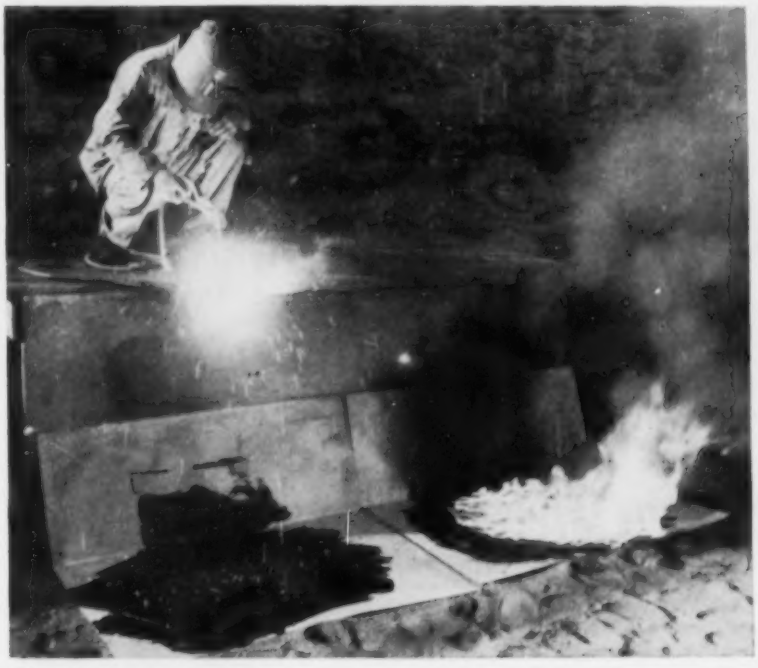


Fire-Resistive Coating

Helps Prevent Plant Fires

Fire-resistive "Mastic 60-60N" is a new combination of non-asphaltic polymers in non-flammable solvents and is the only mastic of its kind accepted by Underwriters Laboratories for listing as fire-resistive, according to the manufacturer.

Tests show the new material is non-flammable when wet; when dry and exposed for two minutes to kerosene flame, it stops smoldering within seven seconds after removal of the flame. Its resistance to prolonged heat is claimed superior. Picture above shows the new mastic (left) has superior fire resistant qualities over conventional mastic (right). Accidental ignition of wet mastic is a common occurrence on new construction and refinery maintenance.

The dry mastic retains maximum flexibility and resistance to chemicals indefinitely. It is an excellent vapor barrier for cold insulation, having a vapor permeance of 0.02 perm. Obtainable in natural resin or in aluminum, the mastic can be painted over without a sealer coat. **Benjamin Foster Co.,** 4635-37 W. Girard Ave., Philadelphia 31, Pa.

Circle No. **1** *on Reply Card*

Magnetic Plate Clamp

. . . permits easy welding of butt and lap joints on uneven plates of steel.

The Porto-Magnetic plate clamp is a self-contained unit combining a powerful magnetic base and fast operating jack. It allows one man to align heavy plates and still have both hands free for welding. The use of support clamps and driving wedges is eliminated.

Operating on either 110 or 220 volts the plate clamp exerts a magnetic force of 3,000 lbs. Thus clamped securely to the steel plate, the attached ratchet-lever jack can be used to straighten any warped section for welding to the steel plate. After the welding is finished the magnet is released by turning off the current. One man can easily move the portable plate clamp. A built in eye-bolt permits using the same clamp as a magnetic lifting unit. **Portomag Sales, Inc.,** 1511 E. Nine Mile Road, Ferndale 20, Mich.

Circle No. **2** *on Reply Card*

Color Test Unit

. . . for aviation gasoline uses a set of ten special glass color standards mounted in two discs. Each pair of these standards provides the minimum and maximum intensity for the standard colors—red, blue, green, brown, and purple—used in gasoline grades.

In testing for color, a sample of the finished gasoline is placed alongside a sample of uncolored base stock. The glass standards, representing the minimum and maximum intensity of the required color, are alternately placed above the uncolored base stock sample. A beam of light is directed through the sample and color standards. Visual inspection quickly tells whether the finished sample falls within the minimum and maximum specifications.

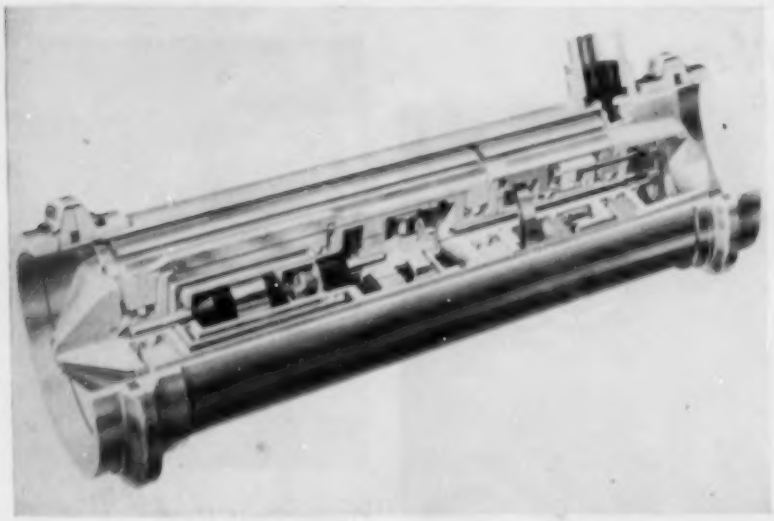
The method, approved for military aviation gasoline tests by the Bureau of Aeronautics, U.S. Navy, provides a simple and accurate color test. **Ethyl Corp.,** 100 Park Ave., New York 17, N.Y.

Circle No. **3** *on Reply Card*

Colored Slide Rule

. . . reduces eyestrain. The new light-alloy slide rule eliminates violet and red rays which focus in front of and behind the retina of the eye. The green-yellow shade is said to coincide with the optimum sight point of the spectrum, thus cutting eyestrain, blurring and errors in reading calibrations. The alloy construction is non-corrosive, non-rusting and non-binding. Slide rules made in 6 and 10 in. trig, log-log standard rules, or to special order. **Pickett & Eckel, Inc.,** 1109 S. Fremont Ave., Alhambra, Calif.

Circle No. **4** *on Reply Card*



Mass Flowmeter

Continuously "Weighs" Fluids

This instrument provides a continuous reading of flowing liquids and gases, and does not depend on such variables as density, temperature or viscosity.

The "Inertial Mass Flowmeter" measures flow by imparting a known, constant angular velocity to the fluid flowing through the meter. The torque required to stop this rotation is directly proportional to the mass flow and is measured by means of a calibrated spring whose deflection is proportional to the torque. This deflection is sensed by a signal generator and results in a voltage proportional to true mass flow. The flow rate or total flow is read on a dial indicator. **Inertial Instrument, Inc.,** 2029 Broadway, Santa Monica, Cal.

Circle No. **5** *on Reply Card*

Rolled-In-Tubes

. . . are formed by expansion after the one-piece strip of brass or copper containing them is stamped, drawn or otherwise fabricated.

As the result of new rolling-mill techniques, metal strips are now produced that contain expandable tubes running the length of the strip. Designated as "Tube-In-Strip" the new mill product is made from a single casting billet. It looks similar to other strip and roll products. But incorporated within it are portions which can be expanded into channels of various crosssections. It is even possible to expand the channel on one side only, leaving the other side flat.

Tube spacing can be as close as ¼ in. or as wide as the metal strip permits. At present the strip is obtainable in 16 in. widths. The inside diameters of the tubes vary from 3/16 to ⅝ in. when unexpanded. The same piece of metal may have different size tubes. Wall thickness will vary from 0.0025 in. to whatever the inflation pressure permits.

Inflation of the tubes is done with air or hydraulic pressure. If freely inflated the tubes will be round. A profile die can be used for other desired tube crosssections. The Tube-In-Strip is available at present in copper, brass and aluminum, with other metals promised in the future. The picture above shows a strip with only 5 tubes expanded. The tubes in the bottom section of the roll have not been expanded. **Revere Copper and Brass Inc.,** 230 Park Ave., New York 17, N.Y.

Circle No. **6** *on Reply Card*

Glass and Steel Heater

. . . for corrosive liquids uses steam within the shell.

Any corrosive acid, except hydrofluoric, can be heated to a temperature of 200°F within the ¾-inch glass tubes. Live steam can be introduced at a temperature of 450°F into the steel jacket that surrounds the 26 glass tubes. The tubesheet assembly is held in place by a Monel brand retainer ring and steel flanges. Studs are spring-loaded to maintain a constant sealing force on the gaskets. The shell baffles are of asbestos.

Units field tested for 18 months have carried heat loads of 975,000 Btu/hr. Overall heat transfer coefficients have been measured up to 175 Btu/(hr.)(sq. ft.)(°F) in water-to-water tests. A single unit assembled and

How we S-T-R-E-T-C-H valve life

Every Powell Valve comes with a long, dependable life built-in. We make certain that every Powell Valve will give long, trouble-free service through careful quality control of every step of manufacture.

Quality control begins with the very materials and metals of which Powell Valves are made. For instance, the tensile strength test—stretching metal to the breaking point—is one of the numerous ways that *Powell Valves have Performance Verified.*

As a final step in manufacture, every Powell Valve is subjected to *an actual line test.* Because of Powell's painstaking quality control, plant shutdown through valve failure is greatly reduced. Records from refineries, power and industrial plants the world over prove it.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our COMPLETE *quality line* which has PERFORMANCE VERIFIED.

The Wm. Powell Company

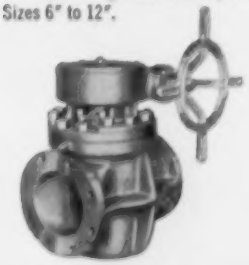
Cincinnati 22, Ohio . . . 110th YEAR

PERFORMANCE PV VERIFIED

FIG. 3003—Steel Gate Valve For 300 Pounds W.S.P.

FIG. 375—Bronze "White Star" Gate Valve For 200 Pounds W.S.P.

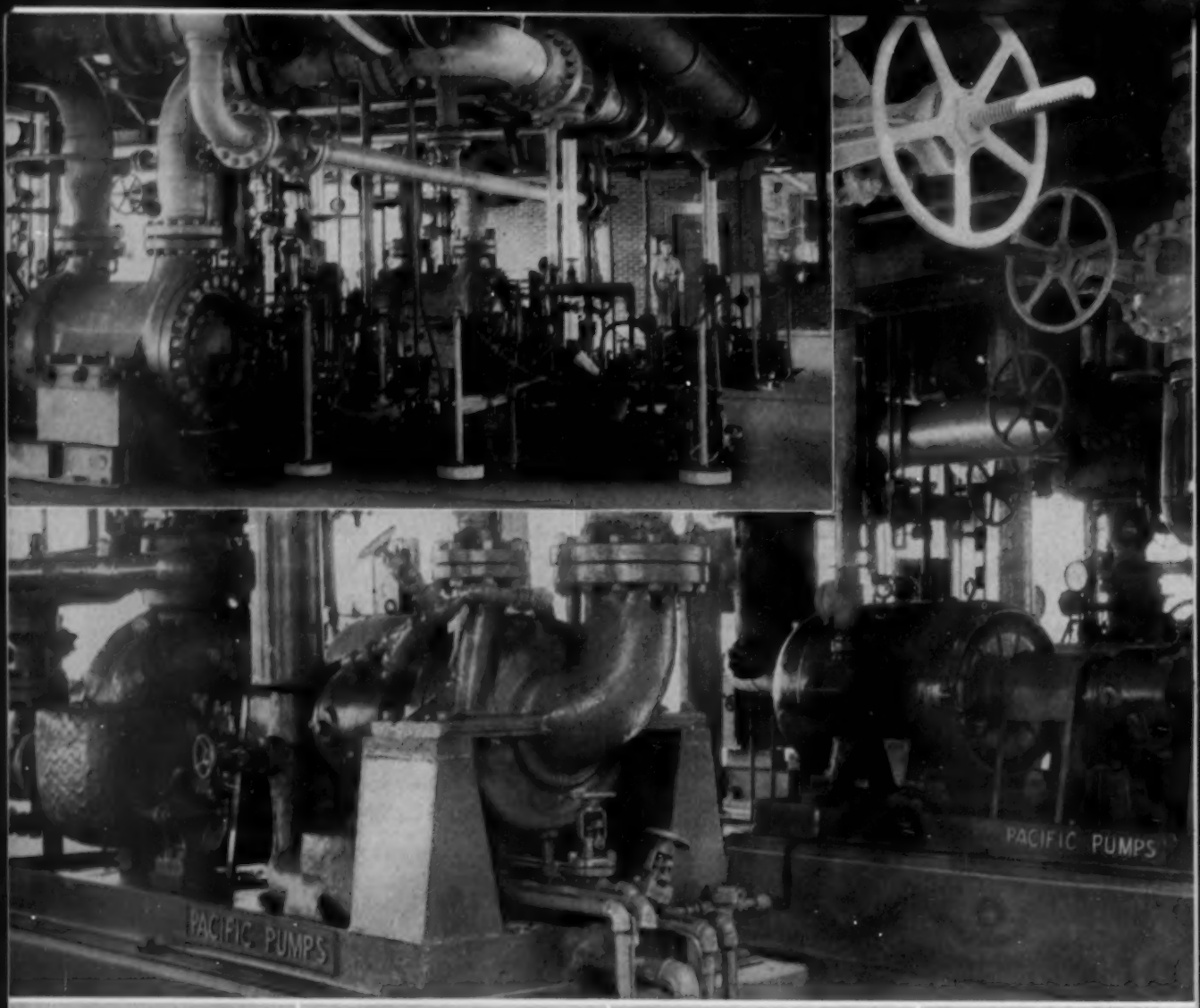
FIG. 3059G—300-Pound Steel Lubricated Plug Valve Gear Operated. Sizes 6" to 12".



POWELL VALVES

BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES.

(To obtain more data on advertised products see page 182)



IDECO

IDECO, Dallas, Tex.—Hydrair and Power Rigs; Full-View Masts; Substructures; Single, Dual and Drive-In Rambler Rigs; Blocks, Swivels, Rotaries; Mud Pumps; Petroleum Equipment and Supplies.

Magcobar.

MAGNET COVE BARIUM CORP., Houston, Tex.—Magcobar and Magcogel drilling muds and other specialized oil well drilling fluids and chemicals.

Security

SECURITY ENGINEERING DIVISION, Dallas, Tex., Whittier, Calif. — Rock bits, reamer rock bits and hole openers; reamers, casing scrapers and Neo-Red rubber stabilizers.

CLARK

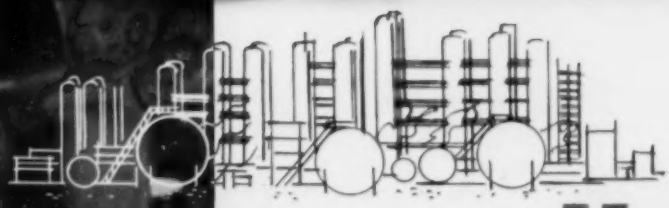
CLARK BROS. CO., Olean, New York—Gas turbines, engines, and reciprocating, centrifugal and axial flow compressors — gas, steam, electric and diesel driven.

ONE OF THE DRESSER INDUSTRIES

PACIFIC

the pump with the extra "oomph"

For more than thirty years, Pacific has supplied the refining, processing, and other industries with a range of pumps for every purpose. In the petroleum industry, Pacific pumps handle everything from the production of crudes to the finished, marketable product. For every industry, Pacific offers a rugged, durable pump for practically every purpose ... single-stage, multi-stage, horizontal and vertical types, with axial and radial split cases ... for all pressures and for extreme sub-zero temperatures and up to 850°F. Whatever your pumping requirements, you can rely on a Pacific pump to handle the work efficiently and economically.



How the DRESSER *plus* + works...

Throughout the petroleum and petrochemical industries, products of Dresser companies are teamed together to help produce and process the fuels and chemicals so vital to the modern world.

For instance, at Shell Oil Company's Deer Park, Texas refinery, Pacific process pumps team up with Clark heavy duty, barrel type multi-stage centrifugal compressors handling recycle hydrogen on reforming service. These Pacific SVC pumps shown in the large illustration have capacities to move many thousands of gallons of liquid per day. The Clark compressors illustrated at upper left are the first of these Clark barrel type units placed in operation.

In this Pacific-Clark equipment team the operators obtain the important Dresser *Plus* + . . . the dependability of equipment insured by the combined experience, research, engineering facilities and resources of the Dresser companies. This is realized in greater strength, better service, powerful stamina, and longer life.

You can get the Dresser *Plus* + by specifying Dresser products and equipment . . . the standard of comparison the world over.

ROOTS-CONNERSVILLE BLOWER DIVISION, Connersville, Ind.— Rotary positive blowers, gas pumps, centrifugal blowers, exhausters, and positive displacement meters.

LANE-WELLS CO., Los Angeles, Calif., Houston, Tex., Oklahoma City, Okla.—Electric and Radioactivity Well Logging, Koneshot perforating and bullet perforating, packers and bridging plugs.

DRESSER-IDECO DIVISION, Columbus, Ohio — Radio and television broadcasting towers, steel buildings, aircraft hangars, mechanical parking garages, electric power substations.

DRESSER MANUFACTURING DIVISION, Bradford, Pa. — Pipe line couplings, pipe repair sleeves and clamps, weldments, forgings, welding fittings, flanges, rings.

DRESSER INDUSTRIES, INC.

OIL, GAS, CHEMICAL AND ELECTRONIC EQUIPMENT AND SERVICES

REPUBLIC NATIONAL BANK BUILDING • POST OFFICE BOX 718 • DALLAS 21, TEXAS

• Edited by GEORGE BLACK

AKH #3 NOW AVAILABLE

How to maintain close dimensional accuracy, fine interior and exterior finish and uniform soundness in the casting of a 1¼ lb. stainless steel instrument housing is told in the latest case history in the Cooper Alloy Advanced Know-How series. Ask for AKH #3 and get the full story on the use of shell mold and shell cores in the production of one of those "impossible" castings.

BUNA N FITTINGS

Vanton's line of Buna N and natural hard rubber fittings is described in a newly revised four-page condensed catalog. Diagrams, dimensions, and application data are included. Ask for Bulletin BN.

INQUIRIES AT ALL TIME HIGH

The demand for technical literature of value is on the increase. Our librarian reports more than 20,000 individual pieces of literature requested during the past twelve months, and we're glad to know that we are serving the needs of so many plant operating and purchasing people. For a quick glance at the most recent publications available on request, write for Technical Literature Folder TL56.

OUR FACE IS STILL RED

We're still apologizing to the many people who have requested our deluxe stainless steel valve and fitting catalog. The demand not only exceeded our supply but our ability to process them as well. Even with daily overtime and Saturday work we still haven't caught up with requests . . . so please forgive us if you're one of those on the waiting line.

COOPER ALLOY
CORPORATION • HILLSIDE, N.J.

installed requires a space measuring 14 in. by 14 in. by 12 feet. These units may be mounted horizontally or vertically for series or parallel flow in the tubes.

The glass tubing can be easily cleaned by recirculating a dilute solution of hydrochloric acid. **Corning Glass Works,** Corning, N.Y.

Circle No. **7** *on Reply Card*

Gas-Liquid Analyzer

. . . **provides automatic analyses** of gases and volatile liquids. It is based on the principle of chromatography.

The Fisher-Gulf Partitioner (trademark) uses a 14-ft. thermostatted chromatographic column to resolve each mixture into its pure components. Each compound is indicated as a separate peak in a spectrum. A built-in integrator simultaneously computes and records a number proportional to the quantity of the component making the peak.

In gas-liquid chromatography, an inert gas such as helium "sweeps" the sample through a column filled with an inert packing, coated with a high-boiling absorbing liquid.

Different components travel at different rates and become separated. As they emerge, they are detected by a thermal conductivity cell, producing a peak on a recorder chart. The area under each peak is proportional to the mole fraction of that component in the sample. The built-in integrator integrates this area automatically.

The Partitioner uses very small samples—0.01-0.03 ml of liquid or 0.3-0.6 ml of gas. It makes a full qualitative and quantitative analysis of a multi-component system in minutes, where distillation takes hours or days. It has a resolving power of a distillation column with more than 1000 "theoretical plates." And it's automatic: simply adjust the instrument, inject the sample, and the Partitioner does the rest.

The Partitioner is supplied with a chromatographic column packed with high-fired graded diatomaceous earth, having a narrow range of particle size. However Fisher will provide interchangeable prepacked columns with other types of packing and liquid coating, on special order. **Fisher Scientific Co.,** 389 Fisher Building, Pittsburgh 19, Pa.

Circle No. **8** *on Reply Card*

Teflon-based Pipe Dope

. . . **prevents galling** and seizing of stainless steel fittings.

Designed for pipe thread fitting assemblies with corrosive and difficult-to-hold liquids, "T-Film®" pipe dope also permits easy disassembly of those alloy threads which often seize. Easy disassembly means that threaded components can be used in place of costlier flanged, gasketed or welded assemblies. In addition to its anti-seize qualities this pipe dope acts as a protective barrier and minimizes galvanic corrosion in dissimilar metal assemblies. **ECO Engineering Co.,** 12 New York Ave., Newark, N.J.

Circle No. **9** *on Reply Card*

Tower Packing

. . . **increases efficiency** of distillation, absorption, scrubbing and stripping. The new material, called "Spraypak," can increase throughout 2-3½ times that of existing bubble tray or ring packed towers.

In large towers, Spraypak is assembled in the form of interlocking horizontal diamond-shaped cells, placed adjacent to and over one another. The

Introducing...

A New Lightweight BS&B Tank Vent And Flame Arrestor *

FEATURES

1 High Capacity

. . . high capacity pressure and vacuum relief comparable to the flow of an open nozzle.

2 Vapor-Tight

. . . one seal only — flexible, positive, replaceable.

3 Rugged with Light-weight Construction

. . . superior design and use of quality materials have resulted in a lighter weight vent.

* PATENT PENDING

The BS&B Type 76-17 Arrestor Vent is a combination vent and cartridge type flame arrestor to prevent the spread of an external flame into the storage tank while venting. The topworks is identical to the Type 76-16 vent (described below), with a modified base to fit the top of the flame arrestor. Clamping edges are interchangeable to allow continued operation of the vent when the arrestor section is removed. Arrestor vents are available in sizes 4" through 12" and mount to ASA bolting circles. Pressure and vacuum settings start at ½ ounce per square inch.

The BS&B Type 76-16 Tank Vent is a lightweight venting device for atmospheric storage tanks containing volatile fluids, and features a floating seal which provides positive shut-off under both pressure and vacuum. This seal consists of two flexible diaphragms which contact valve seats. Easy access is provided to it by a quick-opening V-clamp which holds the cover in place. These vents mount to ASA bolting circles in sizes 4" through 12". Pressure and vacuum settings start at ½ ounce per sq. in.

The BS&B Type 76-18 In-Line Arrestor is for a free vent system, requiring a flame arrestor to protect vent lines on process vessels when the emitted vapors are explosive or ignitible. End flanges are 150 lb. ASA in sizes 4" through 12".

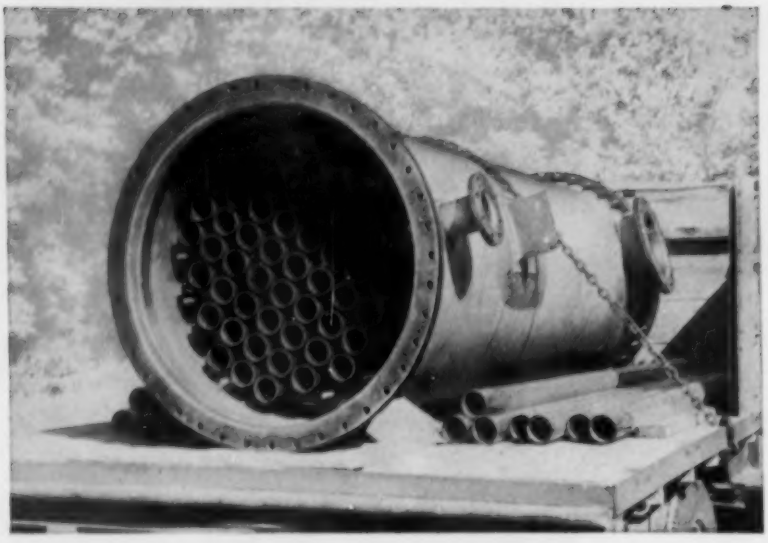
BS&B

Your BS&B Representative will be glad to give you detailed information. Or you may write to . . .

BLACK, SIVALLS & BRYSON, INC.

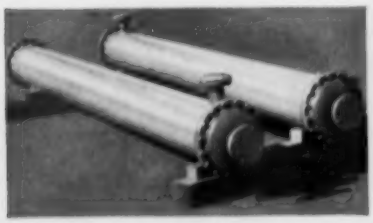
Controls Division, Dept. 2-D3

7500 East 12th Street **Kansas City 26, Missouri**

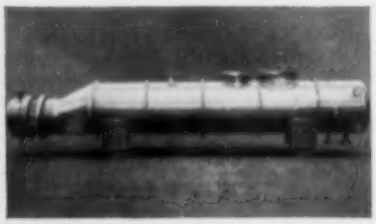


Special heat exchanger materials are well known at Downingtown!

Enamel-Lined Tubes. This stainless steel heat exchanger, with enamel-lined tubes, solved a serious set of problems which included high temperatures . . . heavy corrosion . . . intermittent operation . . . and a tight budget. It now operates at 150% of design capacity, at a temperature of 1200° F.—and the owner reports trouble-free service from his Downingtown unit. Dimensions: 28" diameter x 10' 0" long. Stainless steel shell. Tubes: 3½" O.D., lined with high temperature enamel.



Ampco 8—Downingtown engineered these two fixed tube sheet benzene condensers for export. Process conditions required copper alloy tube sheets, yet the customer did not want a gasketed joint between tube sheets and shell flanges. So we welded the Ampco 8 tube sheets directly to the steel shells, thus saving the cost of alloy shells. Dimensions: 14" diameter x 12'0" long. Eighty copper tubes, 1" O.D. x 14 gauge. Ampco 8 tube sheets ⅞" thick. Ampco 8 heads ⅝" thick. Design pressure is 75 psi on shell and tube sides.



Solid Nickel—This solid nickel reboiler for vacuum service—one of eight identical units fabricated for one customer—was engineered by Downingtown to use a minimum amount of scarce and expensive materials. The double tube sheet construction required special assembly techniques. Notice the large nozzles, which were installed with a minimum of distortion by using proper care and skill during welding. Made of ¼" solid nickel. Dimensions: 34" diameter x 17' 0" long. Has 292 nickel U-tubes, 1" O.D. x 16 B.W.G.

We furnish complete thermal and mechanical designs, or fabricate to your plans. Send now for additional information.

Downingtown Iron Works, Inc.

Downingtown, Pennsylvania

New York Office: 52 Vanderbilt Avenue, New York 17, N. Y.

HEAT EXCHANGERS • TOWERS • PRESSURE VESSELS • STORAGE TANKS • STEEL AND ALLOY PLATE FABRICATION

Division of: Pressed Steel Tank Company, Milwaukee 14, Wisconsin • Manufacturer of Hackney Products

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

walls of the cells are made of a special expanded metal having Venturi-like openings. In the cellular structure formed, the liquid passing down the column flows as a thin film along the walls of the cells into the troughs between adjacent units. Rising gas or vapor mixes with the liquid and intimate mixing occurs between the liquid and the gas. Because Venturi openings cause maximum mixing at minimum permanent pressure loss. Spraypak offers low resistance to flow. This feature maintains effective contacting action down to forty percent of the design loading and gives Spraypak a flexibility approaching that of many tray designs. **S. Blickman, Inc.,** Weehawken, N.J.

Circle No. **10** *on Reply Card*

Ultrasonic Measuring

. . . requiring access to only one side of the material is possible with the "Inspectogage 55."

Offering non-destructive testing of materials, the device gives a visual indication of material thickness. Any flaw due to discontinuity or lack of bonding is indicated by a shift or disappearance of the thickness reading.

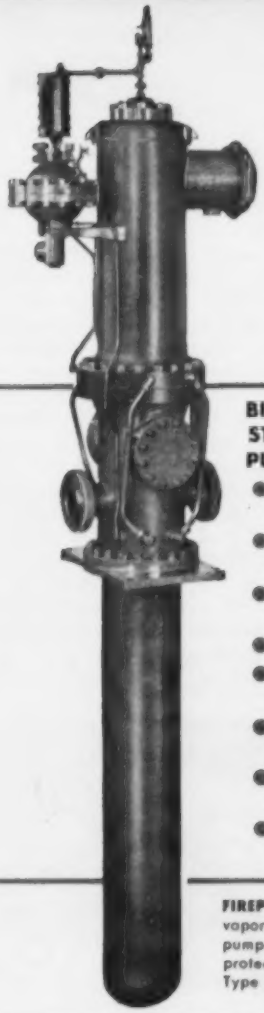
Consisting of an oscillator, cathode ray oscilloscope and transducer, the units weigh approximately 50 lbs. When the frequency oscillator is of the same frequency as the resonance frequency of the material, a vertical marker appears on the face of the oscilloscope and indicates the exact thickness of material.

The unit requires 115 volts, 60 cycles for operation. On the standard model the search unit scans four ranges between 0.025 in. and 0.3 in. Calibrated screens are provided for each of the ranges. **Alcar Instruments, Inc.,** 17 Industrial Ave., Little Ferry,

Circle No. **11** *on Reply Card*

Bingham STUFFINGBOXLESS PUMPS

HANDLE LIGHT HYDROCARBONS* AT HIGH SUCTION PRESSURES



NO STUFFING BOX! NO PACKING!

Bingham Stuffingboxless Pumps are successfully handling liquids having high vapor pressure, requiring high suction pressure and, frequently, abnormally low pumping temperature (—300°).

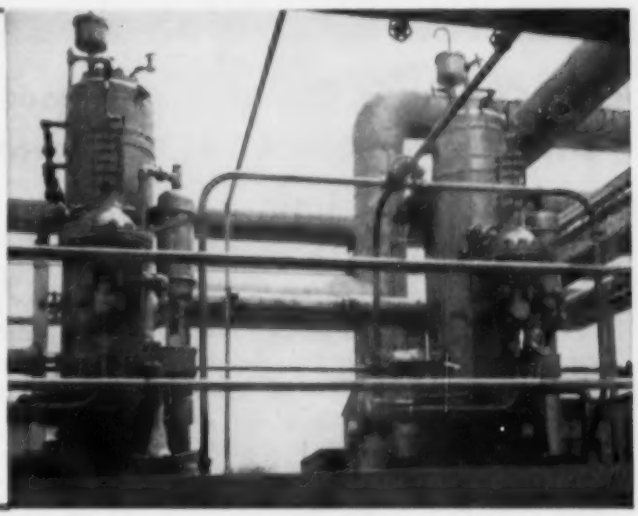
Standard models handle suction pressures up to 2,000 psi (higher pressures available). Pumping temperatures to 850° F. and higher also can be handled.

Bingham Stuffingboxless Pumps are in service today all over the world, with distinguished records in reliability, continuity of service, and low maintenance. Write to your nearest Bingham office for Bulletin 107 or for additional information.

*And other volatile liquids.

BINGHAM STUFFINGBOXLESS PUMPS OFFER:

- Lower overall installed cost
- Less operating attendance
- No misalignment of moving parts
- Smooth operation
- No auxiliary lubricating system
- No exposed moving parts
- Positive motor cooling
- All parts are accessible



FIREPROOF AND EXPLOSION-PROOF! Leakage of vapor to atmosphere or leakage from outside into pump is impossible. Not only is plant and personnel protected, but loss of valuable pumpage is prevented. Type KT Multi-Stage Stuffingboxless Pump illustrated.

Battery of Bingham Type KT Stuffingboxless Pumps handling light hydrocarbon at low temperature, under high suction pressure. Tennessee Gas Transmission Co. plant, Gabe, Kentucky.

Bingham SINCE 1921

BINGHAM PUMP COMPANY

General Offices: 2800 N.W. Front Avenue, Portland 10, Oregon

Factories: Portland, Ore. • Vancouver, B.C., Canada

DOUBLE VOLUTE PUMPS RADIAL BALANCE

SALES AND SERVICE OFFICES

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CHICAGO, ILL.
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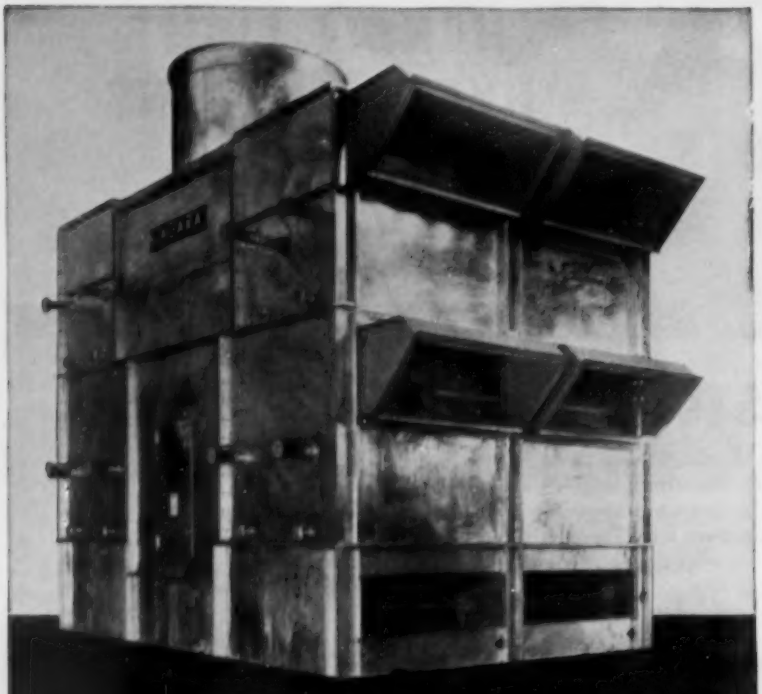
PITTSBURGH, PA.
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
ST. LOUIS, MO.
ST. PAUL, MINN.
TULSA, OKLA.
TORONTO, ONT., CAN.
VANCOUVER, B.C., CAN.

(To obtain more data on advertised products see page 182)

Thirty Million B. T. U. CAPACITY



NIAGARA Aero HEAT EXCHANGER

Cooling in Chemical Processes with Precise Control of Temperature

The NIAGARA Aero HEAT EXCHANGER cools liquids and gases by evaporative cooling with atmospheric air, removing the heat at the rate of input, controlling temperature precisely. You save 95% of cost of cooling water; you make great savings in pumping, piping, power; quickly recover your installation cost.

You can cool and hold accurately the temperature of all fluids, air and gases, water, oils, solutions, chemical intermediates, coolants for mechanical, electrical and thermal processes. You obtain closed system cooling free from dirt. You solve all the problems of water availability, quality or temperature.

In CHEMICAL PROCESSES this is successfully used in cooling liquids and gases, chemical reactions, condensing distillations and reflux cooling.

Write for complete information; ask for Bulletins 120 and 124. Address Dept. PP.

NIAGARA BLOWER COMPANY

405 Lexington Ave. New York 17, N. Y.

District Engineers in Principal Cities of United States and Canada

Gas Analyzer

. . . uses a radio frequency mass spectrometer to identify gases.

Operating on a radio frequency principle instead of the conventional magnet-type mass spectrometer principle, the instrument is designed to monitor refinery process streams and analyze stack and exhaust gases. The instrument is set to the needs of the user, with six different mass selections possible. Tuning to any of the preselected masses or "mass peaks" is accomplished by merely flipping a switch. The gases are sorted and identified by their molecular weights.

An accessory permits cyclic monitoring of the selected masses at the rate of one every ten seconds. **Beckman Division,** Beckman Instruments, Inc., Fullerton, Calif.

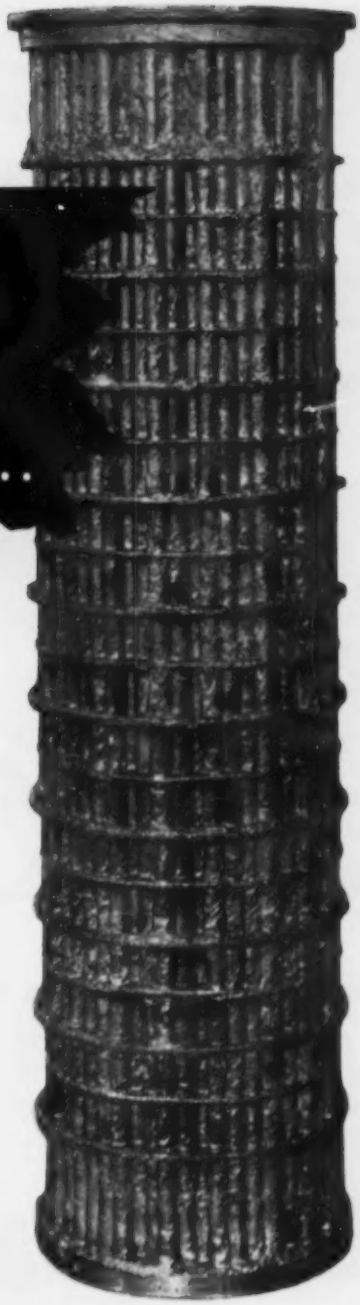
Circle No. **12** *on Reply Card*

Controlled-Tube Roller

. . . expands tubes under automatic control.

The "Torq-Air-Matic" measures output at the output spindle in contrast to conventional expander controls which measure input-output ratio only. The readings are precise and consistent regardless of tubesheet hole variations. Controlled tube rolling without over-rolling or under-rolling,

don't let your heat exchangers get clogged like this...



"IN-PLACE" chemical cleaning now quickest way to maintain bundle efficiency.

With Oakite chemical circulation method you can now clean heat exchangers in place. And here are a few of the many advantages awaiting you:

- fast, thorough soil removal
- greatly reduced off-stream time
- elimination of costly manual methods
- greater safety and longer life for tube bundles
- plus the supervisory services of an experienced Oakite technician
- free drawings and control equipment

For the complete story on heat exchanger cleaning by Oakite send for new 48-page Booklet "What Petroleum Men Should Know to Simplify Cleaning". Or write for the name of your local Oakite Technical Service Representative. No obligation. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

SPECIALIZED INDUSTRIAL CLEANING

OAKITE

MATERIALS · METHODS · SERVICE

SCIENCE

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

FAST

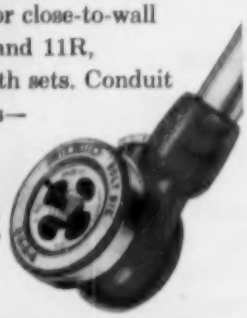
is the word for these efficient little

RIDGID

Drop-Head Dies!

Easy threading of ⅛" to 2" pipe or conduit

Snap size head you want into ratchet drive ring, from either side—it can't fall out. Dies reverse easily for close-to-wall threading. 00R and OR, ⅛" to 1"; 111R and 11R, ⅛" to 1¼"; 12R, ⅛" to 2". Free carrier with sets. Conduit and special dies available. Real work-savers—at your Supply House!



RIDGID Bolt Threaders, too—No. 00R-B, ¼" to 1", National Coarse or fine thread, efficient drop-head dies.

"Threaded Pipe—It's Tight—It's Best—Costs Less"

RIDGID
Work-Saver Pipe Tools

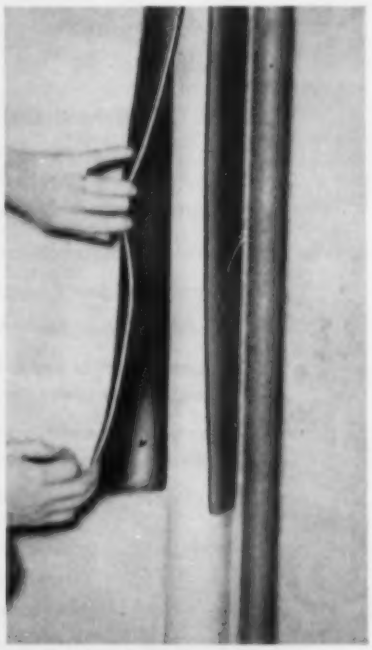
The Ridge Tool Company, Elyria, Ohio, U. S. A.

and without overstressing tubesheets, warpage, and ligament "push-over" is possible.

Completely self-contained, this tool eliminates the need for separate control cabinets, cables and other connections. The only connection needed is the operating airhose. The Torq-Air-Matic will produce 14 ft-lbs torque at 90 psi with maximum consumption of 12 cfm of air.

The basic unit is of the pistol-grip design and is furnished with an auxiliary handle that may be swivelled to any position. The total weight of the unit with the auxiliary is about 7½ lbs and the length is 10". Both first cost and maintenance cost of the unit is said to be less than the cost of conventional types. **Thomas C. Wilson, Inc.,** 21-11—44th Ave., Long Island City, N.Y.

Circle No. **13** *on Reply Card*

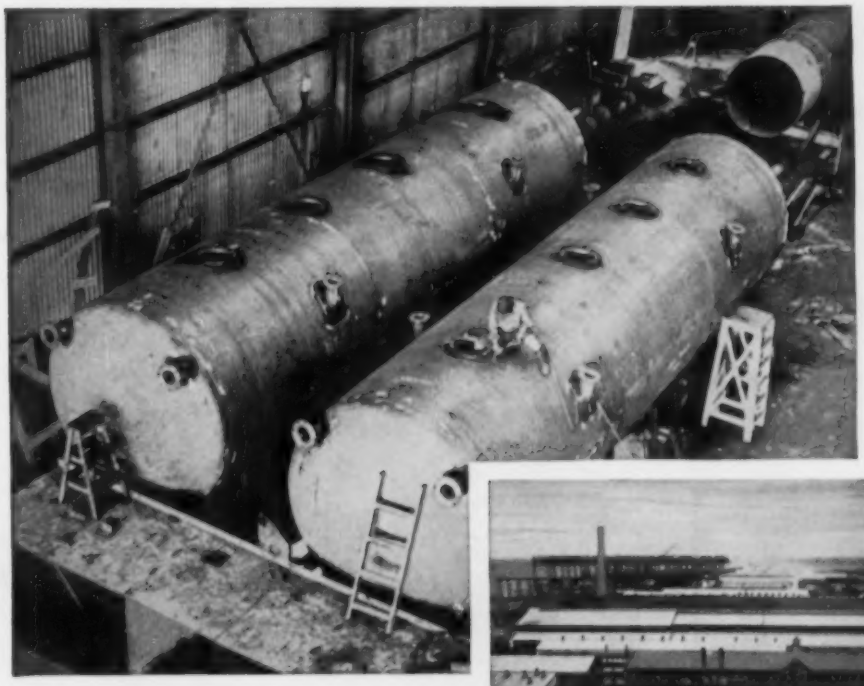


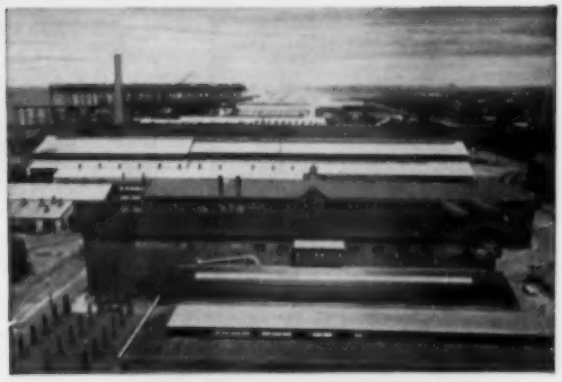
Snap-On Pipe Jacket

. . . made of polyethylene protects insulation on hot and cold lines.

Precut to 6 ft. lengths and preformed to different diameters, "Pip-Jac" is fitted around pipe insulation and springs shut by itself. Longitudinal seams are fastened with ordinary staples; circumferential seams are sealed with adhesive tape of the same material. Using this method it is claimed that one man can completely jacket more than 200 lineal feet of line in 8 hours.

Available in black or decorator-grey





A Mile of Shops – Each shop is devoted to a special type of heavy production. Included are complete Machine Shops, casting, forging and other facilities which offer all of the advantages of the execution of the complete job.

A half mile of pressure vessels

These are two of seventy – over ½ mile – of 38½-foot vacuum tank casings built to meet the quality requirements of a well-known processor.

The buyer also benefits from many savings made possible by Newport News extensive heavy fabrication equipment and the sixty years experience in using it.

Do you plan installations of heavy production equipment? You can command the services of Newport News for weldments of corrosion-resistant, alloy and clad metals in almost any size or shape, plus the required engineering background and complete welding and stress-relieving skills.

It will pay you to get the facts, shown in *Facilities and Products*. As you glance at its photos and brief captions, you'll see why Newport News can turn out – at low cost – specialized heavy equipment for process plants.

Send for *Facilities and Products* – free – today.

Newport News
Shipbuilding and Dry Dock Company
Newport News, Virginia

BROOKS LEADERSHIP *achieved by design*

dowel-pins are the difference

NO TORQUE

NO LINE STRAIN

8 stainless steel dowel-pins precisely align the side plates and end fittings, are the keys to quick, trouble-free assembly and maintenance of the Brooks Full-View* Rotameter. The metering tube is installed after the frame is completely assembled. Tube breakage due to line strain and misalignment is thereby eliminated. It's as simple as placing a round peg in a round hole.

This feature, if considered alone, would make dowel-pin, side-plate construction your most important rotameter specification.

Send for Bulletin 115

*Trade-Name

TM

a complete line... BROOKS ROTAMETERS *...for every service*

BROOKS ROTAMETER COMPANY

107 EIGHTH STREET • LANSDALE, PA.

colors, the polyethylene jacket resists damage from heavy blows and will not chip or rust. No painting is necessary. The same pipe jacket can be removed and used again when maintenance on the pipe lines is required. Since it is made of polyethylene the jacket also provides a natural vapor barrier. **Pip-Jac Co.,** 295 Beverly Road, Pittsburgh 16, Pa.

Circle No. **14** *on Reply Card*

Flash Proof Faucet

. . . for use with flammable fluids has no metal-to-metal contact.

Made of stainless steel with a protective, corrosion resistant anti-flash screen in the nozzle, the new faucet has chemically inert Kel-F seal rings. All frictional contact is limited to these plastic seal rings which move against the inside walls of the body chamber.

The fume-tight faucet permits full flow and has positive shut-off action which prevents after-drip. The shank is supplied in interchangeable sizes of ⅜, ¾ and ½-in., with tapered threads that allow a tight fit in bung threads. **Economy Faucet Co.,** 12 New York Ave., Newark, N.J.

Circle No. **15** *on Reply Card*

Surface Thermometer

. . . reads to a maximum temperature of 1000°F, and is made of stainless steel.

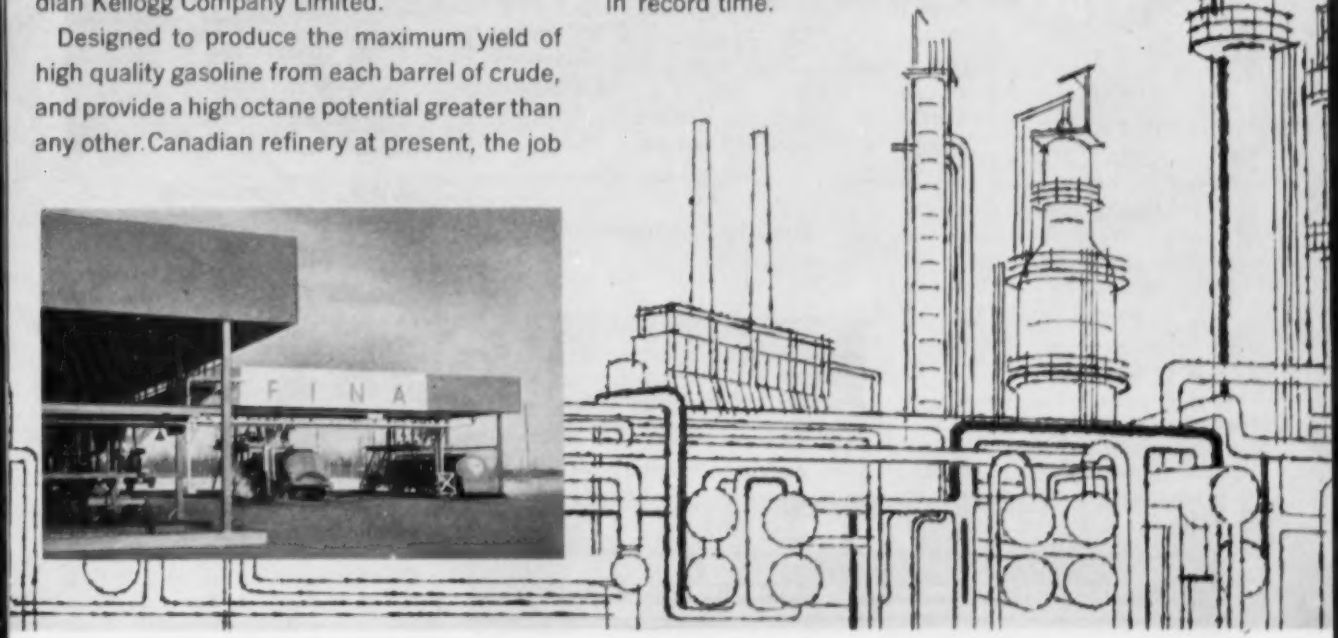
Within 60 seconds of placing the instrument on the surface to be checked, the thermometer will read the temperature accurately to within ±2%. It can be used on all surfaces, such as heavy sheet metal, boilers,

Helping Another Oil Refiner Grow —with Fewest Growing Pains

In building a major petroleum refinery, the main problem is to minimize the time the multi-million dollar investment is non-productive. In the case of M. W. Kellogg's engineering and construction responsibility for Canadian Petrofina's first refinery, near Montreal—which included seven of the nine process units, dock construction, administration buildings, tankage, boiler house, and complete terminal facilities—there were many time hazards. Complicated further by a severe winter climate, and by shortages of steel —solved through Kellogg's overseas resources, this important project was a challenge well met by The M. W. Kellogg Company and The Canadian Kellogg Company Limited.

Designed to produce the maximum yield of high quality gasoline from each barrel of crude, and provide a high octane potential greater than any other Canadian refinery at present, the job called for maximum coordination of engineering, procurement, and construction schedules. For example, in four months almost four million dollars worth of materials and tools were on the site, and 1200 artisans were at work—under the direction of just one resident manager.

With construction started in the Spring, Canadian Petrofina's marketing facilities were in use well ahead of the St. Lawrence freeze-up, and all other facilities were in operation on schedule. We welcome the opportunity to demonstrate the Kellogg organization's ability to assume responsibility for major refinery projects anywhere in the world and complete them in record time.



REFINERY PROCESS DIVISION

THE M. W. KELLOGG COMPANY

225 BROADWAY, NEW YORK 7, N. Y.

The Canadian Kellogg Company, Ltd., Toronto • Kellogg International Corporation, London

SUBSIDIARIES OF PULLMAN INCORPORATED

M KELLOGG W

TC CUPRIC CHLORIDE

PRODUCED BY THE TENNESSEE CORPORATION

MINERS OF COPPER, ZINC, IRON AND SULFUR.

For Removal of Sulfur Compounds in Petroleum Refining.

CUPRIC CHLORIDE DI-HYDRATE

CONTRACT REQUIREMENTS SOLICITED . . .

We are in a position to supply your needs on annual, semi-annual, or monthly contract basis—also smaller quantities in drop shipment lots.

TYPICAL ANALYSIS

Copper	37.00% Minimum
Moisture	12.00% Maximum
Fe	.04% Maximum
Zn	.01% Maximum
Water Soluble	more than 99.50%
Insoluble as copper oxychloride	less than .50%

CHECK THESE *FEATURES:*

- √ HIGHER COPPER CONTENT
- √ LOWER MOISTURE
- √ FINER PARTICLE SIZE
- √ UNIFORMITY
- √ AVAILABILITY

FOR

1. Quality Improvement
2. Cost Reduction

Other Tennessee Corporation products, Ferric Sulfate (Ferri-Floc), Copper Sulfate, and Sulfur-Dioxide.

For Samples . . . Make request on your company letterhead.

TENNESSEE TC CORPORATION

617-29 Grant Building, Atlanta, Georgia

A NEW, EASY WAY TO ORDER REPRINTS

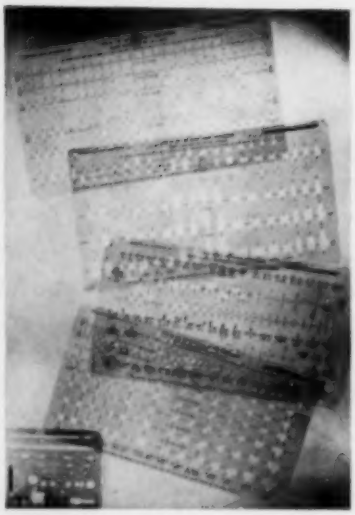
You can now use the Reader's Service Card in this issue of PETROLEUM PROCESSING to order reprints. Here's how:

- Check the list of reprints on page 184.
- Circle the proper "R" letter on the Reader's Service Card (Area "C").
- Fill in your name and address—and send the card to us.

We'll bill you with the reprints

large steam pipes and other surface with temperature ranges between 50 and 1000°F. Beside surface temperatures, it will read ambient temperatures in enclosed spaces as well as in non-corrosive liquids and gases. The diameter is only 1¾ in. and the weight ⅓ oz. **Pacific Transducer Corp.,** 11836 W. Pico Blvd., Los Angeles 64, Calif.

Circle No. **16** *on Reply Card*



Drawing Templates

. . . for piping layouts will simplify drafting room operations.

Available as a matched set of five reversible templates, these drafting aids include all commonly used pipe and valve symbols needed for any piping layout. Usable for ⅛, ¼, and ½-in. to-the-foot drawings, the templates cover symbols for all valves and special fittings used in from ½ to 12-in. size lines.

A complete kit consists of four fitting templates and one dimensioning template; the set is priced at $13.50. The larger templates sell individually for $3.50 each. All are made of rigid, non-glare vinyl. **A Lawrence Karp,** 16 Putnam Park, Greenwich, Conn.

Circle No. **17** *on Reply Card*

Plastic Pipe Fittings

. . . are chemically inert to a wide variety of corrosives. They are made

ALUNDUM*

High-Purity Fused Alumina

How can you use it to advantage?

Among the many electrochemically refined materials produced by Norton Company, ALUNDUM fused alpha alumina is one of the most widely useful to industry. Thanks to its inherent properties of hardness, chemical stability and high density, engineers in various fields are finding many new applications for it.

Norton fused alumina is produced in a number of forms. Of these, 38 ALUNDUM* grain has proved particularly successful in applications demanding high purity. Electrically fused from Bayer-processed alumina, this white grain is shown by typical chemical analysis to be 99.49% pure Al_2O_3. It is insoluble in common solvents and extremely resistant to reduction. It is an amphoteric refractory and has high dielectric strength. Other characteristics include:

Melting point	**about 3600°F.**
Specific gravity	**3.94**
Crystal structure	**hexagonal system (rhombohedral division)**
Hardness	**9.0 Mohs' scale**
Index of refraction	**1.76 mean**

Typical Product Applications in which Norton high-purity fused alumina is now working out to advantage are:

For Catalytic Reactions. Norton fused alpha alumina carriers are outstanding for chemical stability and resistance to abrasion and erosion. Available in the form of spheres, rings and pellets they are used both in fixed bed oxidation reactions and as inert, low-density carriers for space filler applications where a low surface area (less than $1 m^2/gm$) is required. Other types of ALUNDUM catalyst carriers having surface areas in the range 5-60 m^2/gm are also available.

In Pebble Heaters. ALUNDUM heat exchange pebbles are giving excellent results in pebble heaters for heating gases above operating temperatures permissible in conventional tube furnaces. Their great resistance to abrasion, impact and repeated heating and cooling make them the ideal heat transfer medium in these devices. Also, their high refractoriness prevents them from the softening and "bridging" together that causes stoppages in the heater's moving bed.

In Thermal Cracking Reactors. Particularly in Wulff Process Generators for cracking light hydrocarbons to produce acetylene gas and Koppers-Hasche Generators for cracking light hydrocarbons to produce a variety of gases and petrochemicals — checkers made of Norton ALUNDUM high-purity fused alumina provide definite advantages. Their excellent heat transfer properties, high refractoriness and resistance to erosion caused by hot gases are important. Their ability to withstand the thermal stresses of intermittent operation assures long life. And their purity prevents side reactions with the reacting gases, thus safeguarding product quality.

In Gas Synthesis Generators. ALUNDUM fired shapes are ideal for lining generators of this type. Among the inherent characteristics of Norton high-purity fused alumina that work out very well are: high refractoriness, chemical stability, and inertness that prevents reacting with the contacting atmospheres.

Very many other uses for Norton high-purity fused alumina materials include: pure oxides and sintered refractories, refractory cements, wear-resistant parts, laboratory ware, coatings for rocket and jet plane parts and atomic energy equipment.

Other Norton Electrochemically Refined Materials

include CRYSTOLON* silicon carbide, MAGNORITE* magnesium oxide, NORBIDE* boron carbide, FUSED ZIRCONIA and many others, including a number still under development. These high-melting materials, which have varied applications in many fields, are also the basic ingredients of the famous Norton Refractory Rx's — refractories *engineered and prescribed* for the widest range of uses.

For Your Own Applications Or Developments

Norton Company not only supplies these materials in crude form, but has extensive facilities for processing and fabricating — and is ready to work with you in engineering materials to your particular requirements. A new booklet "Norton Refractory Grain — Electrochemically Refined" contains detailed information. For your copy, write to NORTON COMPANY, Refractories Division, 262 New Bond Street, Worcester 6, Massachusetts.

NORTON

REFRACTORIES

Engineered... Rx... Prescribed

Making better products... to make your products better

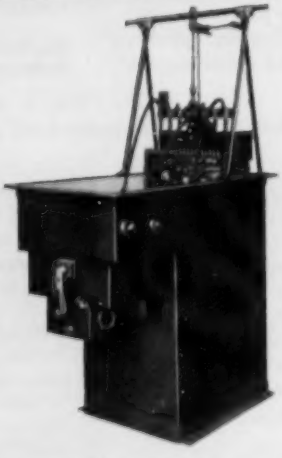
*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

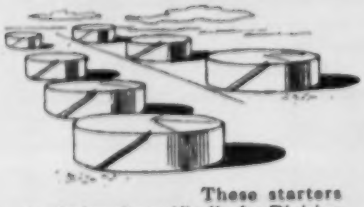
(To obtain more data on advertised products see page 182)

BUILT TO THE REQUIREMENTS OF OIL MEN

EC&M

TOTALLY OIL IMMERSED 50,000 KVA interrupting capacity MOTOR STARTERS have many advantages





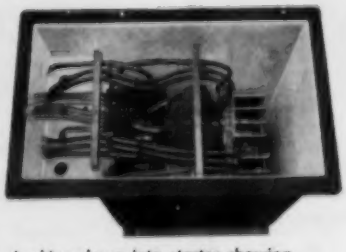
These starters are designed specifically for Division 2, semi-hazardous locations. They are low in first cost and are easy to service when inspection or maintenance are necessary. They require little floor space.

High interrupting capacity is inherent . . 50,000 KVA and no power fuses required. The well-known Type ZHS Magnetic Contactor has been certified for this rating. It is of heavy-duty construction to assure trouble-free operation.

Before buying 2300-5000 volt motor starters, investigate EC&M Type ZHS Starters. They provide economy in installation, operation and maintenance, and are available in a range of horsepower sizes.

Write for Bulletin 1062-20.

Contactor and Relay Panel are bolted together for raising as a unit above the oil. No leads or bolts to disconnect. Shown is Cat. No. 2645A Lifting Mechanism, available at small cost.



Looking down into starter showing anti-syphon lead construction from contactor, control transformer and overload relay panel to conduit connection box with threaded couplings. Starter with oil disconnect switch shown in views above.

EC&M

THE ELECTRIC CONTROLLER & MFG. CO.
Division of Square D Company
4498 LEE ROAD • CLEVELAND 28, OHIO

of "Fluoroflex-T," a fluorcarbon resin.

These fittings are recommended for applications involving acids and caustics, steam, jet fuels, and gases and vapors under extreme conditions of temperature. The pipe elbow is available in 45° and 90° short radius types. The molded bellows come in 1-, 1½-, 2-, and 3-in. diameters. Custom designs and shapes may be requested. **Resistoflex Corp.**, Belleville, N. J.

Circle No. **18** *on Reply Card*

Free Trade Literature

Liquid Level Measurement

. . . in closed tanks: *Bulletin 13-22* tells how to control liquid level by using a differential pressure cell transmitter. Required for connection to the tank are only two small pressure taps; no special fittings are required. The Type 13LA d/p cell transmitter measures the height of liquid in a closed vessel under pressure. The Foxboro Co., Foxboro, Mass.

Circle No. **19** *on Reply Card*

Barometric Condensers

. . . their use, theory and different types: *Bulletin 5AA* covers condenser theory and operation, a description of the parallel and countercurrent flow types, and information pertinent to the selection of condensers under varying conditions. Schutte and Koerting Co., Cornwells Heights, Pa.

Circle No. **20** *on Reply Card*

LP Gas Story

. . . a review of its amazing success and consumption: *LP-Gas, The Cinderella Fuel*, is a brochure written for the layman. It tells the complete story of the gas, from its recovery from crude oil and natural gas to its many uses in the home. Gulf Oil Corp., Gulf Bldg., Pittsburgh, Pa.

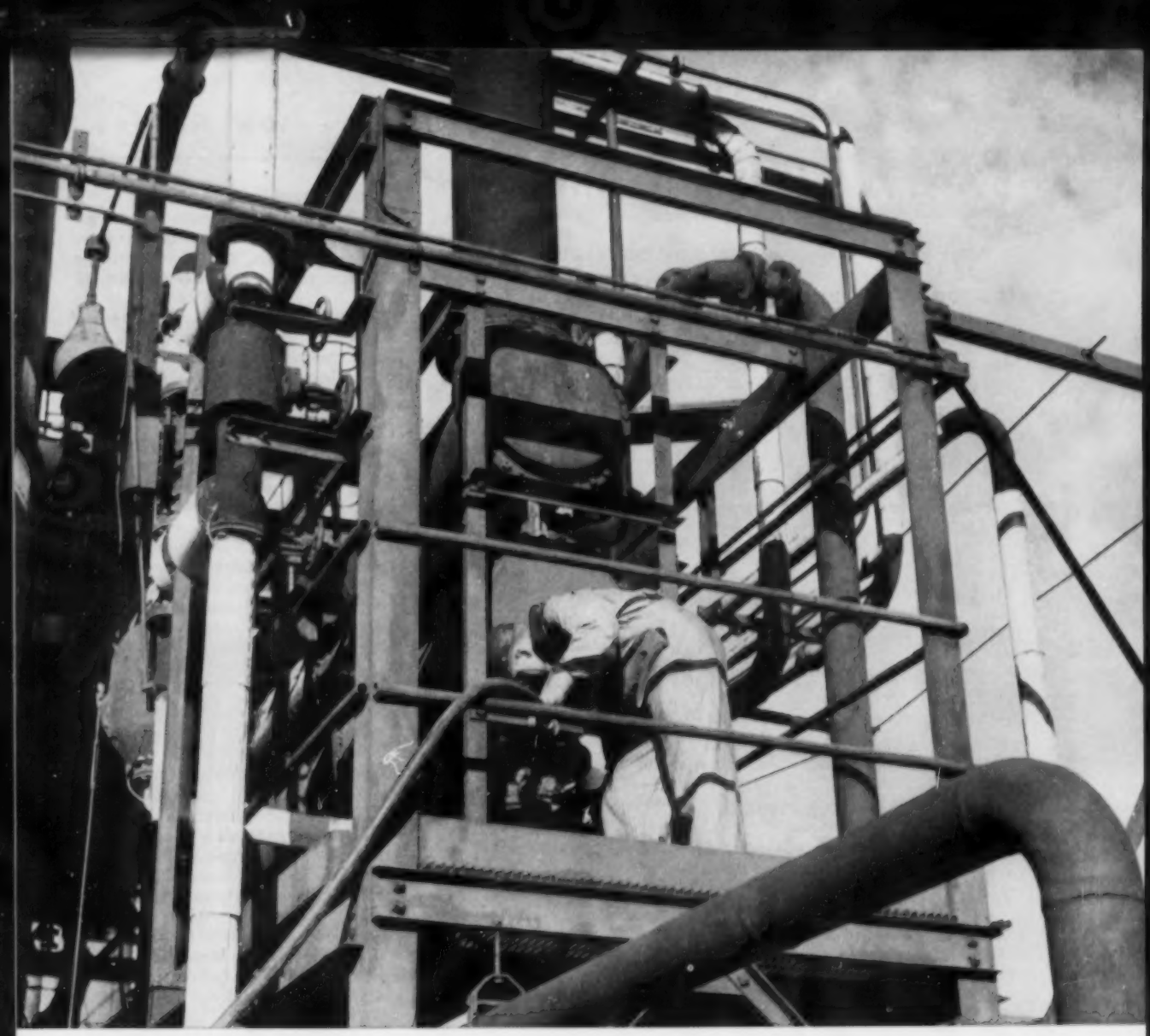
Circle No. **21** *on Reply Card*

Asphaltic Coating

. . . acts as the "raincoat" for vessel insulation: *Bulletin B-26* describes the many applications of "Weathercoat," a cold-applied protective coating for all type of thermal insulation in refineries and chemical plants. Since the material has high resistance to moisture in all forms, both liquid and vapor, it prevents the air cells of thermal insulation from losing their insulating properties. American Bitumuls & Asphalt Co., 200 Bush St., San Francisco, Calif.

Circle No. **22** *on Reply Card*

(To obtain more data on advertised products see page 182)



There's too much at stake —clean it right

Chemical cleaning involves costly equipment and often work stoppages. It's a job for experts. Let Dowell protect that equipment and keep production losses to a minimum when you have scale or sludge problems.

In over 15 years our trained engineers have serviced virtually every kind of equipment in plants, mills and refineries throughout industry. In fact, Dowell has cleaned over 10,000 boilers alone!

This experience means lower costs to you—in more thorough work, restored efficiency and less production loss.

Furthermore, Dowell engineers know you value the safety of your men and equipment. Dowell uses only the latest safety equipment and techniques to eliminate hazards and accidents. Our engineers work closely with your safety personnel to establish the safest possible working procedures.

Call the nearest of more than 165 Dowell offices. An experienced engineer will be glad to talk over and help you with your cleaning problems any time — at no obligation. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Dept. C-32.

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

"Alamask" CASE HISTORY

A well-known oil refinery had an injunction to stop operations of its catalytic cracking unit, due to odors emanating from spills, separators and other wastes, stack fumes and products of combustion. RHODIA was consulted and ALAMASK used. Here is an excerpt from a letter from the refinery:

"Very effective masking of odors resulted and in view of our actions all cases against us were withdrawn. We are very grateful to RHODIA for what they have done for us and are happy to pass on our experiences to others in similar difficulty."

If odors from your refinery are contaminating the community, RHODIA can help you, too. Our experienced odor engineers will be happy to consult with you on your malodor problems.

Rhodia INC. 230 Park Avenue, New York 17, N. Y.

In Canada: NAUGATUCK CHEMICALS, Division of Dominion Rubber Co., Ltd.
MONTREAL • TORONTO • ELMIRA • WINNIPEG

NEED ENGINEERS?

An employment advertisement in our CLASSIFIED advertising section will help you find the engineers you need. It's an inexpensive, time-saving method of contacting competent personnel for every engineering job in refining and petrochemical industries. The select circulation of PETROLEUM PROCESSING offers you an opportunity to choose the best qualified men available. For rates and information write:

Classified Advertising Division

PETROLEUM PROCESSING

330 West 42nd Street New York 36, New York

Industrial Finishes

. . . including maintenance coatings, waterproofings, roof coatings, caulking compounds, and floor patching compounds: 48-page *Catalog No. 56* lists highly specialized coatings to resist alkali, acids, oils and greases. Technical information on paints, rust inhibitors and other industrial finishes is included. Steelcote Manufacturing Co., 3418 Gratiot St., St. Louis, Mo.

Circle No. **23** *on Reply Card*

Waste Heat Exchanger

. . . uses a unique finned design to recover heat from stack gases and refinery vapors or to preheat air or other gases: *G-R News, Summer, 1955* describes the construction of this exchanger, which has extended surfaces on both the shell and tube sides and operates on the cross-flow principle for maximum transfer of heat between gases. Application conditions are pressures up to 100 psi, and 1100°F. The Griscom-Russell Co., Massillon, Ohio.

Circle No. **24** *on Reply Card*

Pneumatic Relays

. . . can perform many functions: *Bulletin AD68* presents a series of applications in process control. Covered are five classes of controls: override, multi-element, impulse, intermittent, and characterizing. Typical examples, several for each class, are presented to show how the Nullmatic M/F Relays have been used for a wide range of control problems. Moore Products Co., Philadelphia 24, Pa.

Circle No. **25** *on Reply Card*

Saving Drafting Time

. . . is the topic of a booklet that compiles ways to use intermediates for drawing revisions: *11 Ways to Save Drafting Time* discusses specific ways that scissor editing, masking, the block-out method, successive additions and pre-printing can reduce drafting time. Techniques discussed apply to various print-making methods including moist-developed, ammonia, blueprint, sepia negative and even the reproduction cloth process. Frederick Post Co., 3666 N. Avondale Ave., Chicago 18, Ill.

Circle No. **26** *on Reply Card*

"Soyez les Bienvenue à Montréal au Mois de Mai!"

NEW

Alumina and other Special Base Catalysts

for special catalyst needs

A wide line of new, extremely hard, Alumina Base Catalysts, as well as synthetic silica-alumina and other special base catalysts, is available. These are manufactured by the Chemicals Division of Houdry Process Corporation to special standards for uniformity, surface area hardness and mechanical strength.

New, Houdry HARD ALUMINA base catalysts include:

- platinum
- cobalt molybdate
- molybdenum oxide
- molybdenum sulfide
- chromium oxide
- nickel oxide
- palladium

For additional information, write on your letterhead to:

HOUDRY
PROCESS CORPORATION
Chemicals Division
1528 Walnut Street, Philadelphia 2, Pa.

PIONEER IN CATALYSIS

(To obtain more data on advertised products see page 182)

For Laboratory Apparatus you can trust...

Look to LINDBERG

Rugged . . . accurate . . . dependable

These are qualities you can be assured are built into the complete line of laboratory apparatus made by Lindberg.

The Lindberg units illustrated here are called "The Royal Family of Laboratory Apparatus." They include:

- . . . G-10 Laboratory Box Furnace (3000° F. Max.)
- . . . B2, B6 Laboratory Box Furnace (2000° F. Max.)
- . . . Laboratory Pot Crucible Furnace (2000° F. Max.)
- . . . Laboratory Hot Plate
- . . . Volumetric Carbon Determinator
- . . . "H-F" Combustion Unit
- . . . Sulfur Determinator
- . . . Laboratory Furnace Controls
- . . . Combustion Tube Laboratory Furnace

All these units are sold exclusively through your Laboratory Equipment Dealer. Consult him when you need laboratory apparatus—his advice and assistance will help you make the right selection for your needs. Or, for further information, write us for our Bulletin No. 1001, which describes in detail the complete line of Lindberg Laboratory Apparatus.

LINDBERG LABORATORY DIVISION

LINDBERG ENGINEERING COMPANY

2481 West Hubbard Street, Chicago 12, Illinois

Water Clarification

. . . by chemical treatment: *Technical Reprint T-138* discusses the important operating factors involved in selecting chemical treatment for water clarification. The theoretical chemical problems of coagulation and the actual physical considerations of the process are both discussed. A test for determining the proper chemical to use is described also. Graver Water Conditioning Co., 216 W. 14th St., New York 11, N.Y.

Circle No. **27** *on Reply Card*

Clay Conduit

. . . for underground steam, hot water, process lines, chilled water and refrigeration piping: new *Bulletin 56* is designed to help in the engineering of underground heat distribution piping. Included are recommended construction and installation methods, with many drawings to show the proper procedures. Heat Transmission Conduit Co., 2300 Payne Ave., Cleveland 14, Ohio.

Circle No. **28** *on Reply Card*

Fire Protection

. . . by the use of installed protective systems: *Engineered Special Hazard Fire Protection* is a 28-page catalog that describes the many factors involved in the detection, prevention, control and extinguishment of fires in hazardous locations. Included are many examples of systems installed in refineries, natural gasoline plants, and loading facilities for flammable liquids. A chart is included that aids in the choice of a fire-fog, airfoam, CO_2, or a dry chemical system. Automatic Sprinkler Corp. of America, Youngstown, Ohio.

Circle No. **29** *on Reply Card*

Adhesives, Coatings

. . . and sealers: recent catalog lists the properties and applications of a wide variety of these materials. Typical applications are listed in tables which are designed for easy use. Listed are characteristics, methods of applications, color, base, solvent, solids content, net weight and company identification. Minnesota Mining and Manufacturing Co., 411 Piquette Ave., Detroit, Mich.

Circle No. **30** *on Reply Card*

Solvent Detergents

. . . their many uses for cleaning: 16-page booklet, *How to Use Oakite Solvent Detergents*, tells how to use them in removing oily films, smuts, synthetic paints from steel, and zinc

(To obtain more data on advertised products see page 182)

we never underestimate the creative in construction . . .

Building petroleum refineries, petrochemical and chemical plants requires complete understanding of practical construction techniques. You know, and we know, that there is no substitute for experience, a thorough knowledge of tried-and-proved methods, in this business. But, there is an important something beyond this, too.

It is the "creative sense" ever present at Procon, the constant seeking for better, more practical, more economical ways to build the most efficient installations for our clients. We are ready to apply this creativeness to your construction problems.

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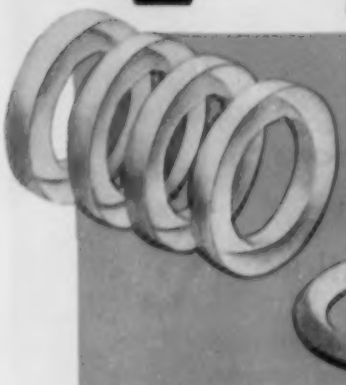
PROCON (*Canada*) LIMITED
TORONTO 18, ONTARIO, CANADA

PROCON (*Great Britain*) LIMITED
LONDON, W. C. 2, ENGLAND

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

V-PACKING for every process need



TEFLON . . .
CHEMISEAL PACKING

Chemiseal V-Rings are all TEFLON,* all low-friction, all-chemical resistant. Distinctive tapered V design offers greater flexibility and resiliency. Provides necessary seal at low gland pressure, reducing torque required to operate valves—imposes less load on reciprocating pump pistons. Outlasts other packings in chemical service, many times over.

Write for U. S. Gasket Catalog TP-1255 on Engineered Teflon Packings.

*du Pont Trademark

BEL-VEE
GENERAL PURPOSE PACKING

The "Pressure-Sealing" V-Ring packing that expands toward rod and stuffing box wall on pressure stroke to automatically form the seal — and relaxes when pressure is released to allow free movement with minimum friction.

For all reciprocating rods and valve stems handling water, oil, solvents, steam, air and gas.

Write for Belmont Catalog 4-R-10 on Self-Sealing V-Ring Packings

United States Gasket Co.
Camden 1, New Jersey

The Belmont Packing & Rubber Co.
Butler & Sepviva Sts., Phila. 37, Pa.

U.S. GASKET · BELMONT PACKING

chromate primers from aluminum—all accomplished without heat. Methods of applications are recommended. Booklet is available if requested on company letterhead from Oakite Products, Inc., 150D Rector, New York 6, N.Y.

Do Not Use Reply Card

Steam Traps

. . . are fully described in a 44-page handbook on condensate drainage: *The Armstrong Steam Trap Handbook* includes engineering, installation and operation tips for better use of steam traps. Typical is the section describing how to trap steam mains, purifiers, pipe coils, unit heaters, submerged steam coils and tubes, and the many other applications for steam traps. Armstrong Machine Works, Three Rivers, Mich.

Circle No. **31** *on Reply Card*

Spectrophotometer Chart

. . . depicts all the accessories that can be used with the Beckman DU spectrophotometer. Included are all attachments, sample compartments, thermospacers and common spare parts arranged to show their interrelationships. Will Corp., Rochester 3, N.Y.

Circle No. **32** *on Reply Card*

Mercury Switch Controls

. . . for heating, refrigeration and other industrial applications: *Mercoid Controls Catalog No. 856* lists and describes all the automatic controls which incorporate mercury contact switches. The 52-page catalog pictures and describes with operating specifications the various types of switches available from this manufacturer. The Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.

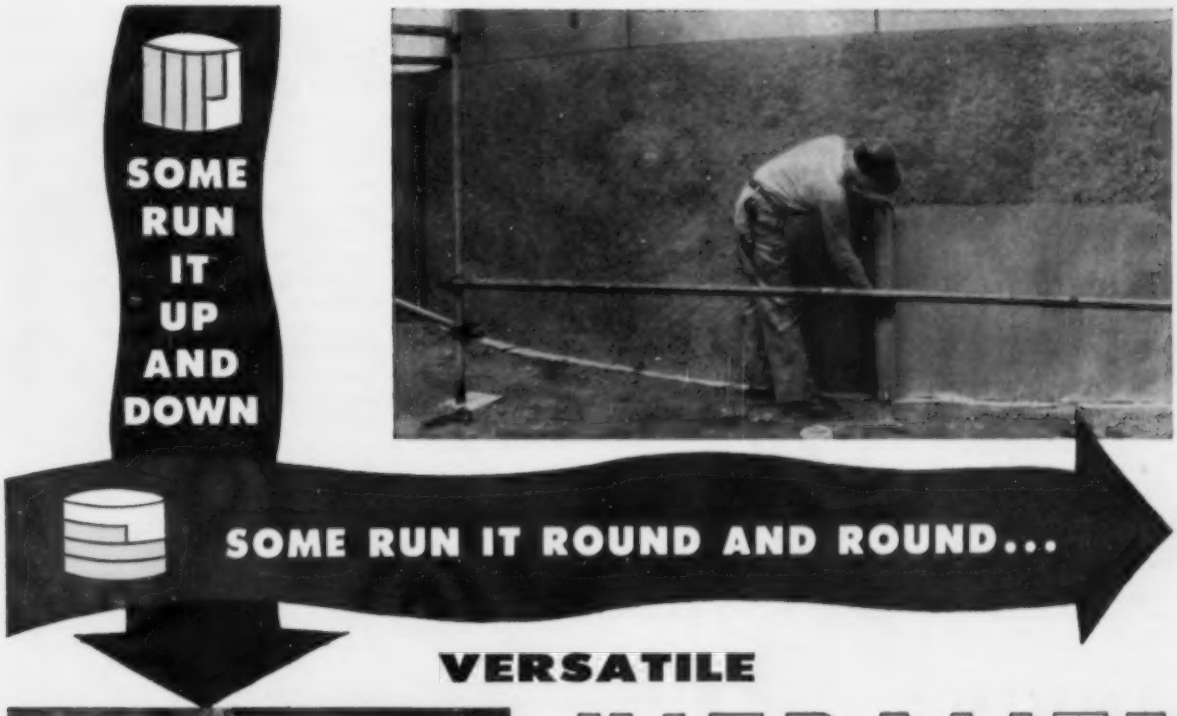
Circle No. **33** *on Reply Card*

Glass Fibers

. . . their many uses and properties: *Form WPD-11* describes and illustrates uses of glass wool blankets for thermal and acoustical treatments. In addition are described its uses as a resilient cushion material, reinforcement for plastics, and as a textile yarn. L.O.F. Glass Fibers Co., 1810 Madison Ave., Toledo 1, Ohio.

Circle No. **34** *on Reply Card*

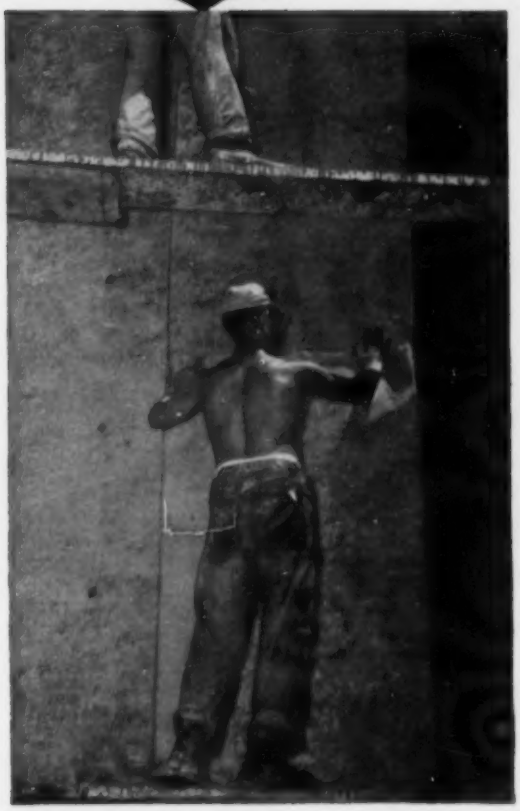
"Soyez les Bienvenue à Montréal au Mois de Mai!"



VERSATILE

ULTRALITE

TANK INSULATION



Techniques of applying Ultralite vary, but everyone agrees that it is by far the fastest and cheapest way to insulate tanks, vats, vessels and other heated equipment.

With blanket rolls up to 10 feet wide, in no time at all you can cover any regular or irregular shaped vessel with this flexible glass fiber insulation. What's more, the vessel will be insulated "once and for all" — for Ultralite is a permanent insulation.

When you consider that labor is by far the big item in insulating, it makes sense to select the insulating material that lends itself to the fastest, easiest application. That material is Ultralite, the only insulation of long textile-type glass fibers. Write today for samples, prices, specifications and suggested application methods.

GUSTIN-BACON *Manufacturing Company* GUSTIN gb BACON

Thermal and acoustical glass fiber insulations • Pipe coverings and fittings • Molded glass fiber pipe insulation

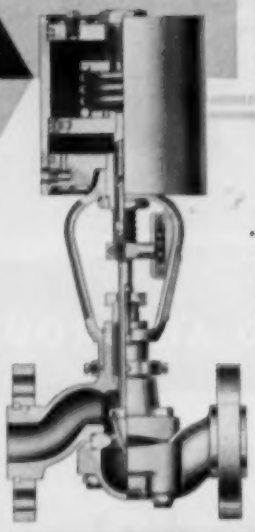
266 W. 10th St., Kansas City, Mo.

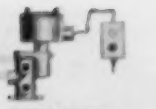
For Remote Shut-off Applications...

ANNIN CYLINDER VALVES

provide the complete answer!

absolute shut-off dependability and safety with **ANNICO TEFSEAL SEATS** proven in dangerous services, such as Liquid Oxygen, Fuming Nitric Acid, Liquid Nitrogen and CO_2, Fuels and other FLUIDS at all pressures and temperatures −300° to +450° F.





ELECTRO-PNEUMATIC SOLENOID PILOT ACTUATED

3-WAY OR 4-WAY MANUAL AIR ACTUATED

PNEUMATIC CONTROLLER ACTUATED

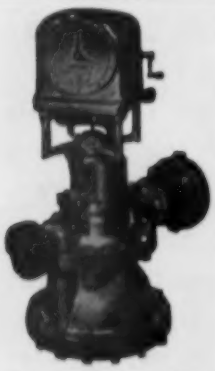
...with these advantages:

- Positive shut-off
- Fast action
- Spring to open or Spring to close
- Globe, angle & 3-way bodies
- Carbon steel and all cast and forged alloys available
- Metal seats for high temperatures

ANNIN *Control* VALVES

THE ANNIN COMPANY

6570 EAST TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA



COMPLETE Jacketed Pipe and Fluidometer Systems

for all liquid-handling problems

● In any processing operation where the maintenance of a uniform temperature in the process pipes is necessary, a Hetherington & Berner jacketed system will assure dependable, economical production. This is equally true regardless of whether the material being handled requires a hot or cold temperature, what heating or cooling medium is used, or whether the material is corrosive or non-corrosive. Write for Bulletin J-50. If you have a liquid batching problem, involving either light or heavy liquids, jacketed or unjacketed construction, investigate the *Fluidometer System.* This system gives accurate, dependable and *completely automatic* batching and is adaptable to practically any liquid measuring problem, whether it involves gallons, barrels or tank cars. Write for Bulletin Fl-49.

H&B ESTABLISHED 1889

HETHERINGTON & BERNER INC.

751 KENTUCKY AVE. INDIANAPOLIS 7, IND.

What's New!

Solid Film Lubrication

. . . is used where difficult lubrication problems exist. New brochure, *Electrofilm Solid Film Lubricants,* presents the results of recent laboratory and research efforts. The process is designed for inhibiting fretting corrosion and preventing galling and seizing for high loads, high speeds and extreme temperatures. It operates from −100°F to +700°F and produces dry, clean and dust free operation. It may be used alone or in conjunction with oils and greases. Electrofilm, Inc., P.O. Box 106, North Hollywood, Calif.

Circle No. **35** *on Reply Card*

PVC Pipe

. . . applications and information: two new folders describe the mechanical, thermal and electrical properties of Alpha 101 and Alpha 102 unplasticized rigid pipe or polyvinyl chloride. Listed in a table are the results of field tests which show the pipe's resistance in many fields. The installation procedures recommended for this plastic pipe and its fittings are included. Alpha Plastics Inc., 15 Northfield Road, West Orange, N.J.

Circle No. **36** *on Reply Card*

Emergency Chart

. . . for the laboratory lists treatments for almost all accidents. Emergency treatment for specific poisons are listed in alphabetical order on this new edition of *Laboratory Emergency Chart,* as well as treatments for specific accidents and chemical burns. Illustrated is the pressure-arm lift method of artificial respiration recommended by the Red Cross. The chart is available to all laboratories if requested by the individual in charge. Address requests directly to Fisher Scientific Co., 389 Fisher Bldg., Pittsburgh 19, Pa.

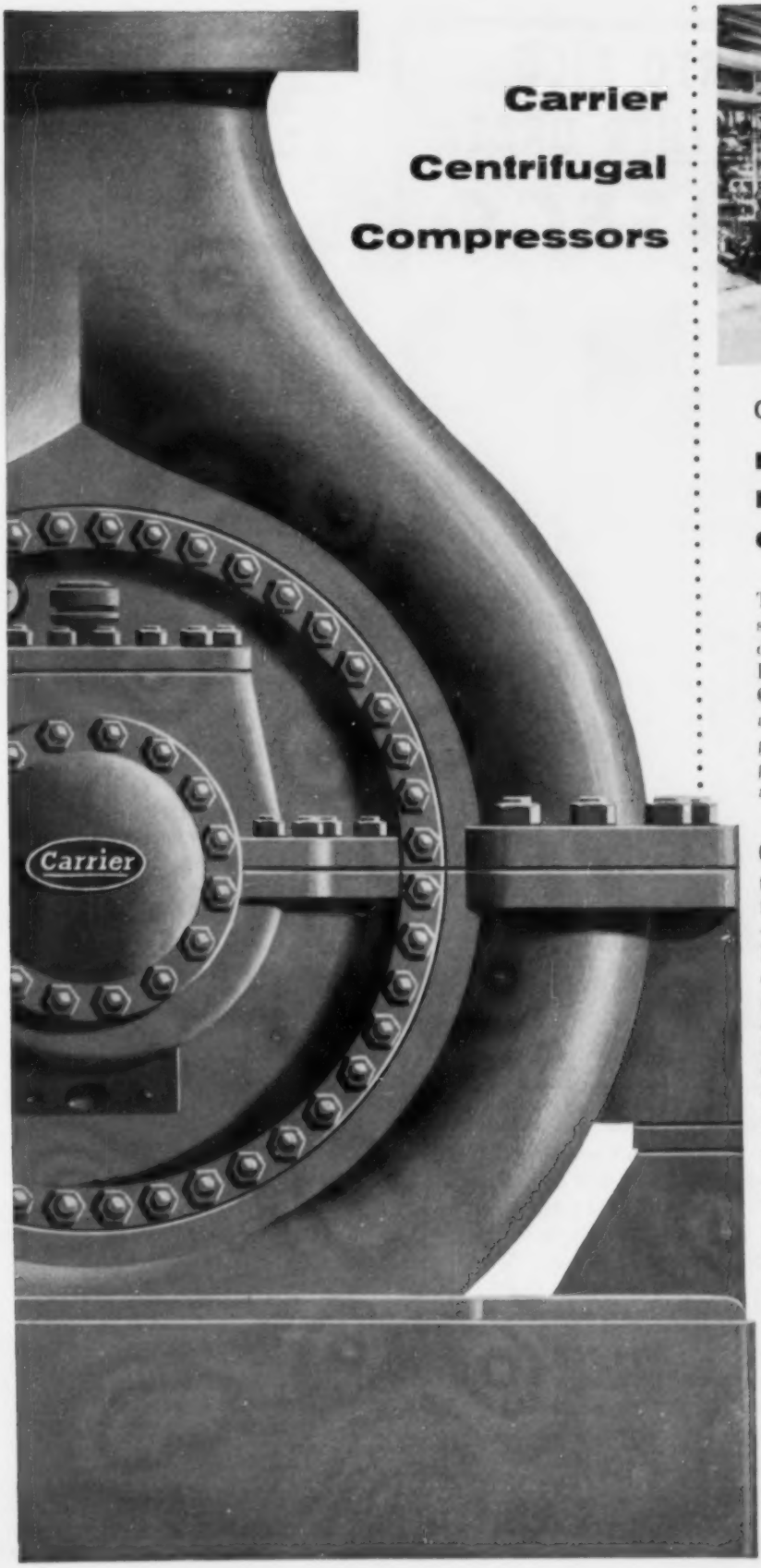
Technical Data Books

. . . in pocket-size: *Lefax Catalog for 1956* lists all the data books which are available for purchase. Some of the subjects covered include metals, piping data, steam engineering, petroleum engineering, hydraulics, and conversion tables. All data books are printed on 6¾ x 3¾ in. sheets. Lefax Publishers, Philadelphia 7, Pa.

Circle No. **37** *on Reply Card*

Solenoid Valves

. . . for air, oil and water service: *Catalog 5-C* lists information on valve characteristics, flow patterns, overall dimensions. Included are tables of or-



Carrier Centrifugal Compressors

on the job at

National Petro-Chemicals Corporation

Twelve Carrier Centrifugal Compressors play important roles in the production of ethylene at the Tuscola, Illinois, plant of National Petro-Chemicals Corporation. These units are used to compress hydrocarbon gases. The duties vary from charge gas compression to recycle streams and refrigeration.

Carrier makes a complete line of centrifugal and axial flow compressors for gas compression and refrigeration—up to 10,000 hp in a single unit. Hundreds of these dependable, efficient Carrier machines are on the job at dozens of chemical plants and refineries throughout the world—Canadian Petrofina, Olin Mathieson Chemical Corporation, Wyandotte Chemicals Corporation, The Texas Company and many others. May we assist *you?*

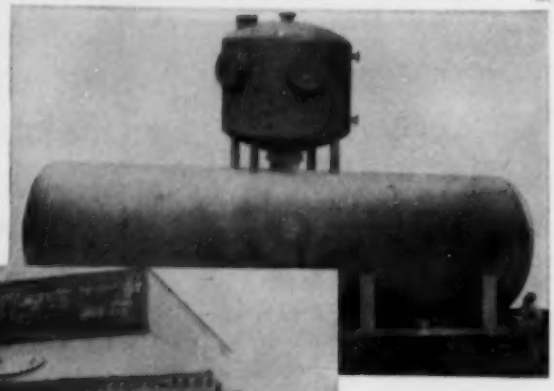
If you'd like a copy of our booklet **"Centrifugal Compressors for Industry"** please call your nearest Carrier office. Or write direct to Carrier Corporation, Syracuse, New York.

Carrier

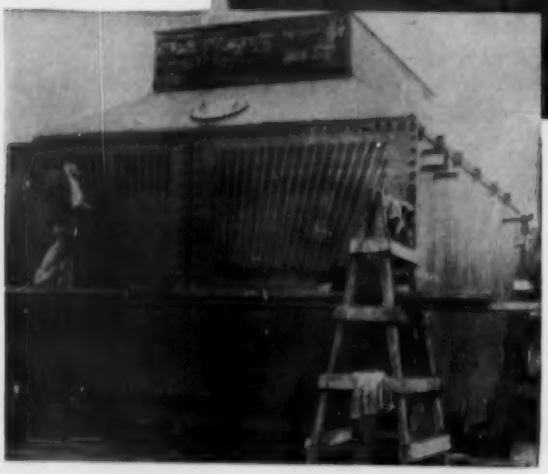
centrifugal compressors
refrigerating equipment

(To obtain more data on advertised products see page 182)

SATISFIED PUERTO RICO SENDS ANOTHER ORDER FOR CONSECO



RIGHT:
500,000 lb/hr deaerating feedwater heater with 22,000 gal. storage tank.



LEFT:
CONSECO supplied a 45,000 sq. ft. condenser, air ejector and hogging ejector for Unit No. 5.

FOR THE SAN JUAN STEAM ELECTRIC STATION

The San Juan Steam Electric Station of the Puerto Rico Water Resources Authority has been so satisfied with Conseco condensing and feed water heating equipment already installed and operating with Units 1, 2, 3, and 4, they ordered additional Conseco equipment, shown above, for Unit 5. The heating section on top of the 36½ ft. storage tank is 9 ft. in diameter, 10 ft. high, A.S.M.E. Code. This is the largest heating unit in the plant, part of the feedwater heating system for the 44,000 KW turbo generator system.

Call on CONSECO for emergency retubing, repairs and maintenance of any tubular equipment . . . any hour, any day (including Sundays, holidays) . . . anywhere on the continent.

CONDENSER SERVICE & ENGINEERING CO., INC. CONSECO

Designers and Builders of Equipment for Power, Refining, Chemical and Marine Industries

54 Bloomfield Street
HOBOKEN, N. J.

dering information and photographs of 3-way and 4-way pilot controlled valves. Pressure range includes up to 500 psi. Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle No. **38** *on Reply Card*

Leak Detector

. . . uses a mass spectrometer of radio-frequency principle to detect, locate, and measure minute leaks: *Beckman Bulletin #17* describes how to use this new instrument in checking evacuated or pressurized vessels for leaks, as well as how it operates in detecting leaks as small as 1×10^{-12} liters/sec. Beckman Division, Beckman Instruments, Inc., Fullerton, Calif.

Circle No. **39** *on Reply Card*

Photometer

. . . determines high molecular weight and small particle size: *Bulletin BP-1000-A* describes in 20-pages the operation of a light scattering photometer that can be used for the measurement of micro-scattering, micro-fluorescence, and very low transmittance and reflectance of dark materials. Using recent techniques it is possible to determine molecular weights of large molecules in solution. Phoenix Precision Instrument Co., 3803-05 N. 5th St., Philadelphia 40, Pa.

Circle No. **40** *on Reply Card*

Temperature Detectors

. . . based on the electrical resistance of certain metals: *Publication No. 3016D* describes the theory, construction and specifications of many types of resistance temperature detectors. These temperature-sensitive elements can be mounted at remote locations, with the signal carried through ordinary copper wire. Thomas A. Edison, Inc., Instrument Div., West Orange, N.J.

Circle No. **41** *on Reply Card*

Process Heating Equipment

. . . using Dowtherm "A" and "E," paracymene, Arclor #1248 and heat transfer oil: *Bulletin DV* describes and illustrates various vaporizers, electrically-heated vaporizers and forced circulation liquid heating and cooling units. These units provide a wide range of accurately controlled temperatures at low pressure. Union Iron Works, Erie, Pa.

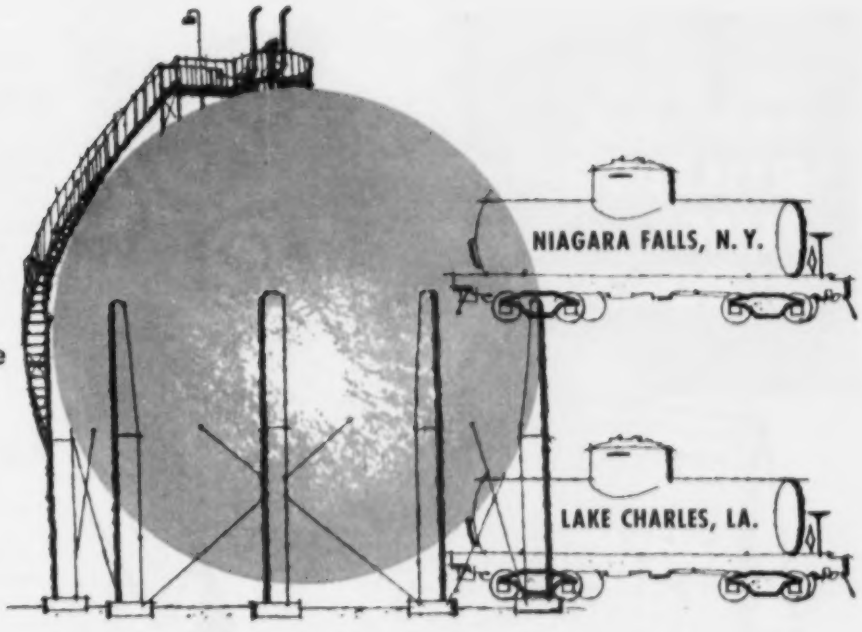
Circle No. **42** *on Reply Card*

"Soyez les Bienvenue à Montréal au Mois de Mai!"

multi-plant production

skilled technical service

traditional quality



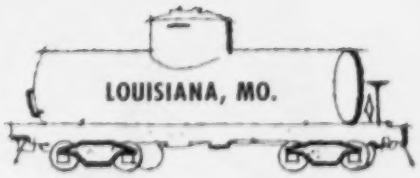
BUY AMMONIA to better advantage from MATHIESON

Require dependable deliveries of ammonia . . . coordinated with your production schedule? It will pay you to order from Mathieson. Here's why:

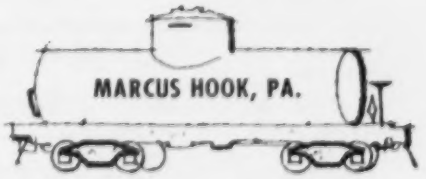
Five shipping points assure maximum protection against supply interruptions.

Expert technical service . . . particularly in the pulp and paper and metals processing fields . . . is always available.

Balanced output to industry and agriculture eliminates seasonal shortages.



Talk over your ammonia requirements with an Olin Mathieson representative soon. Let him show you why more people buy more chemicals to better advantage from Olin Mathieson . . . America's prime producer of basic industrial chemicals.



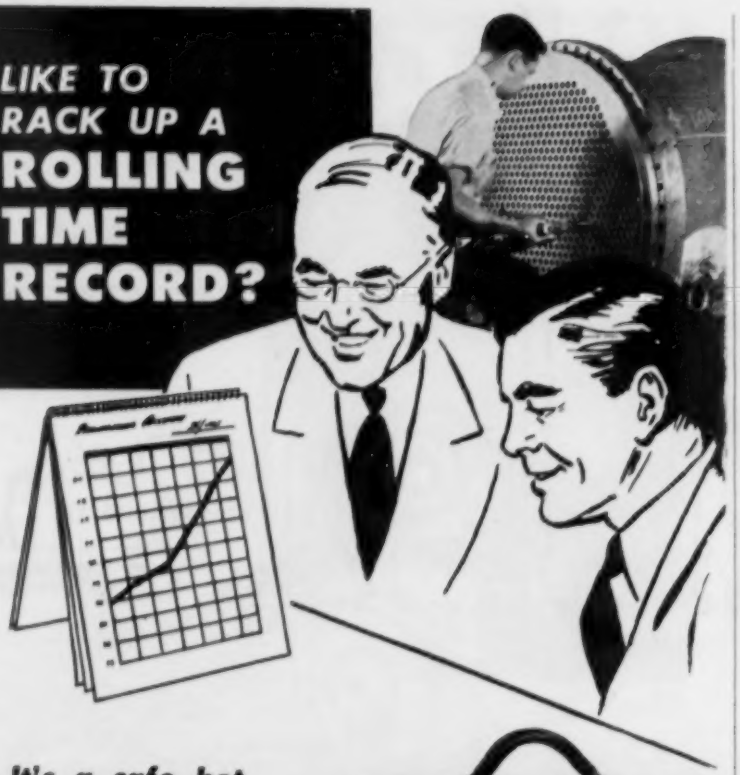
MATHIESON

MATHIESON CHEMICALS
OLIN MATHIESON CHEMICAL CORPORATION
INDUSTRIAL CHEMICALS DIVISION • BALTIMORE 3, MD.

3794

INORGANIC CHEMICALS: Ammonia • Bicarbonate of Soda • Carbon Dioxide • Caustic Potash • Caustic Soda • Chlorine • Hydrazine and Derivatives Hypochlorite Products • Nitrate of Soda • Nitric Acid • Soda Ash • Sodium Chlorite Products • Sulphate of Alumina • Sulphur (Processed) • Sulphuric Acid
ORGANIC CHEMICALS: Ethylene Oxide • Ethylene Glycols • Polyethylene Glycols • Glycol Ether Solvents • Ethylene Dichloride • Dichloroethylether Formaldehyde • Methanol • Sodium Methylate • Hexamine • Ethylene Diamine • Polyamines • Ethanolamines • Trichlorophenol • Trichlorobenzene

LIKE TO RACK UP A **ROLLING TIME RECORD?**



It's a safe bet you WILL... with an AIRETOOL Tube Expansion Control System

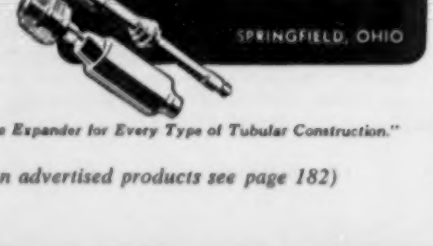
Nothing beats betting on a *sure* thing! And that you do when you rely on the Airetool tube expansion control system. Automatic, the Airetool system with its preset control quickly rolls joints to a uniform tightness. Gives maximum bonding between tube and sheet. Over-rolling is, therefore, eliminated . . . and rolling time is notably shortened, from hours to minutes.

Motors are available in four sizes to supply proper power for your purpose. Entire system is portable.

Call for an ON-YOUR-JOB DEMONSTRATION Today!

BRANCH OFFICES: New York, Chicago, Philadelphia, Tulsa, Houston, Baton Rouge.

REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, England, South America, Puerto Rico, Japan, Italy, Hawaii.
European Plant: Airetool Nederland N.V., Vlaardingen, The Netherlands.



"There's an Airetool Tube Cleaner and Tube Expander for Every Type of Tubular Construction."

What's New!

Deflection Indicator

. . . provides immediate knowledge of any excessive movement on large operating equipment: *Bulletin 05B-8385* describes how the magnetic-amplifier type detector works. The requirements for mounting the unit are a 60-cycle, 110-volt power source and a suitable location for two compact inductor-coil pickup units. Allis-Chalmers Mfg. Co., 836 S. 70th St., Milwaukee, Wis.

Circle No. **43** *on Reply Card*

Metallic Sodium

. . . and how to handle it: 40-page brochure, *Handling Metallic Sodium On A Plant Scale*, is a comprehensive treatment of handling technology. Contained are details such as typical sodium processes, details of equipment installations, safety recommendations, and suggested instrumentation. This manual will aid those engaged in the design or the operation of sodium handling facilities. U. S. Industrial Chemicals Co., Division of National Distillers Products Corp., 99 Park Ave., New York 16, N.Y.

Circle No. **44** *on Reply Card*

Alloys For Heat Exchangers

. . . promise longer life and dependable service: 28-page brochure, *Heat Exchange Problems*, presents the story of typical installations using cupronickel or nickel-copper alloys in evaporators, condensers and feed water heaters. As the nickel content of alloys increase from 10% to near the 70% of Monel, there is a parallel increase in strength and corrosion resistance that allows a choice of material to meet various operating conditions. Reader Service Section, International Nickel Co., Inc., 67 Wall St., New York 5, N.Y.

Circle No. **45** *on Reply Card*

Nickel Alloys

. . . as produced in the largest specialty mill in the world, is the subject of a new booklet, *This Is Inco's Huntington Works*. Tracing the production of high nickel alloys from the mine to the mill, the 47-page book unfolds a complete story of all operations involved. International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Circle No. **46** *on Reply Card*

Tubing Supports

. . . for field installation: *Bulletin No. 955-D* lists the advantages of the P-W

Nicholson *steam trap* capacity *gives you*...

faster, more effective condensate removal

Write, today, for your copy of new Bulletin 10-55—for detailed information.

Nicholson capacity is greater than that of any other trap of the same size. And, greater capacity—right across the board—means the Nicholson trap discharges condensate and air from petroleum process steam lines and equipment *faster*, more *effectively*.

- **powerful valve action—big husky bellows.**
- **positive shut-off—finely ground valve and seat.**
- **high capacity—effective use of large orifice.**
- **each unit service tested—with steam.**

When less than the best won't do, specify Nicholson.

NICHOLSON

W. H. NICHOLSON and Company

TRAPS • VALVES • FLOATS • METAL PARTITIONS
LAUNDRY, DRY CLEANING AND PRESSING MACHINERY

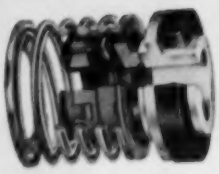
14 OREGON STREET, WILKES-BARRE, PA. • SALES AND ENGINEERING OFFICES IN 98 PRINCIPAL CITIES

3 JOHN CRANE Shaft SEALS

for lifetime performance in any petroleum or petrochemical service

TYPES 1 and 2

Synthetic Rubber Bellows • For Low Pressure Service



Services: gasoline, diesel fuel, fuel oil, crude oil, butane, propane, ethane and similar products non-injurious to synthetic rubber.

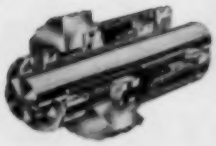
Pressures: to 200 psi.

Temperatures: −40°F to +212°F.

Construction Data: Factory assembled. Self-adjusting sealing head. Lapped faces positively prevent leakage. Low spring pressure for minimum wear. *Available in balanced construction for pressures to 550 psi.*

TYPE 8B

Packaged Type Seal • For High Pressure Service



Services: Same as Types 1 and 2.

Pressures: to 1200 psi.

Temperatures: −40°F to +250°F.

Construction Data: Heavy duty. Hydraulically balanced to handle high pressures. Single-unit package for easy installation.

TYPE 9

Sealing Members Made of Teflon* • Engineered for service conditions that do not permit use of rubber

Services: alkyl benzine, benzine, creosote, silicone oil, some petroleum derivatives, and all known corrosives.

Pressures: to 150 psi. (balanced construction to 750 psi.)

Temperatures: −120°F. to +500°F.

Construction Data: Furnished in the metallurgical specification best suited to the particular service. Flexible wedge ring and sealing ring molded from chemically inert Teflon.

Contact "John Crane" for the shaft seal best suited to your requirements. Request bulletin giving full information on "John Crane's" complete line of mechanical seals.

Crane Packing Co., 6432 Oakton St., Morton Grove, Ill., (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

*DuPont trademark

JOHN CRANE **CRANE PACKING COMPANY**

system for running instrument tubing, as well as the standard units available. Dimensions, recommended loadings, and general specifications are included as an aid to designers. P-W Industries, Inc., 4500 E. Melrose St., Philadelphia 24, Pa.

Circle No. **47** *on Reply Card*

Did You Miss These?

The following items, reviewed originally in November, have aroused considerable interest among the readers. They are repeated briefly as a service to those who might have missed them the first time they appeared. For details or literature, please use the regular Reply Card in this issue.

Ultrasonic Flow Meter

. . . uses controlled sound waves to measure the flow of almost any liquid, for either volume or mass. The new flowmeter is not affected by flow variables and offers virtually no pressure drop in the pipe line.

The rate of volume flow is measured by two transducers, each of which transmits and receives controlled pulses of ultrasonic energy across a section of pipe. One is aimed upstream and the other downstream. An increase in the liquid flow rate increases the number of downstream pulses received and decreases the number of upstream pulses. Since the repitition rate of these pulses cancels out sonic velocity by heterodyne techniques, the difference in the number of impulses is proportional to the flow of velocity.

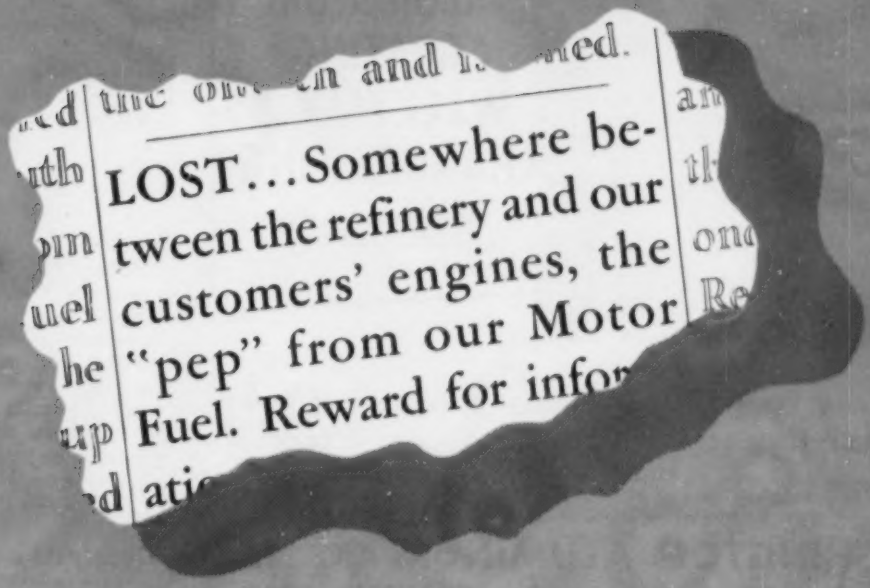
Available meters have a capacity up to 12,000 lb/min. with a fluid range of approximately 2.5 to 1. Standard operating conditions are −50 to 225°F. and 150 to 300 psi. Fischer & Porter Co., Hatboro 35, Pa.

Circle No. **48** *on Reply Card*

Pulsation Dampener

. . . is claimed to be twice as effective but occupies only one-sixth the space of older type dampeners. The heart of the new "Desurger" pulsation dampener is a rubber sleeve, which works with throttling orifices that circle the main flow line. During pressure surges the sleeve is distended against a precharge of air, forcing liquid through the throttling orifices and dissipating the excess pressures.

The new dampener works against a



Blend WARREN NATURAL GASOLINE with your present high quality Motor Fuel to give it the

RETAINED VOLATILITY

so necessary for superior performance after it reaches your customers' fuel tanks.

WARREN

PETROLEUM CORPORATION

TULSA, OKLAHOMA • Cable Addresses: STAVOLENE, WARREN

EXPORT TERMINALS: CORPUS CHRISTI, PORT ARTHUR, BAYTOWN, TEXAS CITY AND WARRENGAS, HOUSTON, TEXAS, SAN PEDRO, CALIF.

ALUMINUM GRATING WALKWAY & HANDRAILING

A typical installation frequently used in the petroleum industry.

See us also for:

- Pressure Vessels
- Storage & Processing Tanks
- Heat Exchangers
- Towers
- Gratings

Our pressure vessels and tanks are designed and built to comply with the requirements of the ASME code and we are authorized to apply the appropriate symbols.

WASHINGTON ALUMINUM CO., Inc.

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HOUSTON: Blackstone 6388
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NEW ORLEANS: Raymond 9744
SAN FRANCISCO: Yukon 6-2803
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PHOENIX *Drop-Forged* FLANGES MEAN...

MAXIMUM STRENGTH

Long life is assured with Phoenix maximum strength flanges. Forged of mild steel, they are available in a wide range of styles and sizes. Meet ASA requirements and ASME and ASTM specifications.

NEW CATALOG!
Send for free brochure showing Phoenix Complete Line.

FLANGE DIVISION
PHOENIX MANUFACTURING CO.
Catasauqua, Pa. • Joliet, Ill.

maximum pressure of 2,000 psi and is designed to protect instruments, valves, fittings and pipe against pressure surges and pulsations. The manufacturer also says that field tests prove that the unit will increase the flow capacity of lines by reducing turbulences that retard smooth flow of liquids. Industrial Products Div., Westinghouse Air Brake Co., Wilmerding, Pa.

Circle No. **49** *on Reply Card*

Level Indicator

. . . operates warning lights or pumps through explosion proof switches. The movement of a foam plastic float on the indicator stem actuates the switches as it passes pre-selected points on the stem. The head assembly of the unit is a standard pipe plug, allowing installation on most tanks. Gem Co., 64 Welles Drive, Newington, Conn.

Circle No. **50** *on Reply Card*

Catalysts of Molybdenum

. . . are described in a 24-page booklet. Reactions which may be catalyzed by molybdenum compounds, commercial processes now using these catalysts, and factors to be considered in selecting one of these catalysts are discussed. Climax Molybdenum Co., Dept. L, 500 Fifth Ave., New York 36, N.Y.

Circle No. **51** *on Reply Card*

Silica Gel Dessicant

. . . for dehydration of air and gas: 15-page *Technical Bulletin No. 201* has charts, diagrams and tables describing the advantages of using silica gel for natural gas installations. Davison Chemical Co., Div. of W. R. Grace & Co., Baltimore 3, Md.

Circle No. **52** *on Reply Card*

Hydraulic Tables

. . . and other engineering data: 28-page reference book for those interested in pumping and piping problems. A new edition of this handbook. Aldrich Pump Co., 25 Pine St., Allentown, Pa.

Circle No. **53** *on Reply Card*

Suntide Refinery

. . . at Corpus Christi, Tex.: the subject of a brochure issued by the Lummus Co., designer and constructor of this recent project. The 15-page booklet describes each of the main operating units and auxiliary section, with supplementary photographs. The Lummus Co., 385 Madison Ave., New York 17, N.Y.

Circle No. **54** *on Reply Card*

(To obtain more data on advertised products see page 182)

J-M 85% Magnesia is lightweight . . . easy for workmen to install half-sections on this 10" steam line. Insulation work at the Grace Chemical plant was performed by Young Sales Corporation of St. Louis. Engineering and construction was directed by Foster Wheeler Corporation of New York.

Your Btu's and dollars go further when you specify **Johns-Manville 85% Magnesia**

. . . the choice of insulation engineers at Grace Chemical's new Memphis plant

INDUSTRY'S LONG-TIME standard for temperatures to 600F is still your best insulation buy. For J-M 85% Magnesia provides high insulating value, easy application, long life, initial low cost and minimum maintenance. That's why insulation engineers consistently specify J-M 85% Magnesia for modern installations like Grace Chemical's new anhydrous ammonia-urea plant. That's why it will pay you to specify J-M 85% Magnesia for your new plant or modernization program.

To assure you maximum value from your insulation dollar, Johns-Manville gives you complete drawing-board-to-job-site service. You get expert recommendations by the world's most experienced insulation engineers . . . plus expert installation by authorized J-M Insulation Contractors. Write today for further information on J-M 85% Magnesia and Johns-Manville's unmatched facilities to solve your insulation problems. Address Johns-Manville Box 60, New York 16, N.Y. In Canada, Port Credit, Ontario.

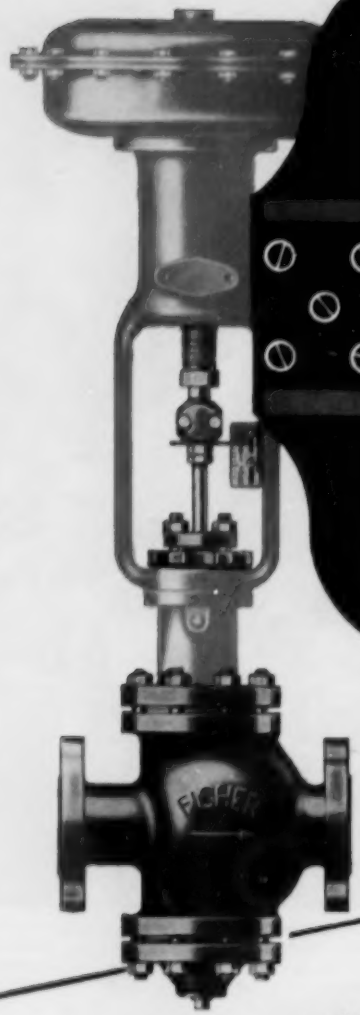
J-M 85% Magnesia also comes in block form. Here you see it being applied to a vertical drum at a New Jersey petroleum refinery.

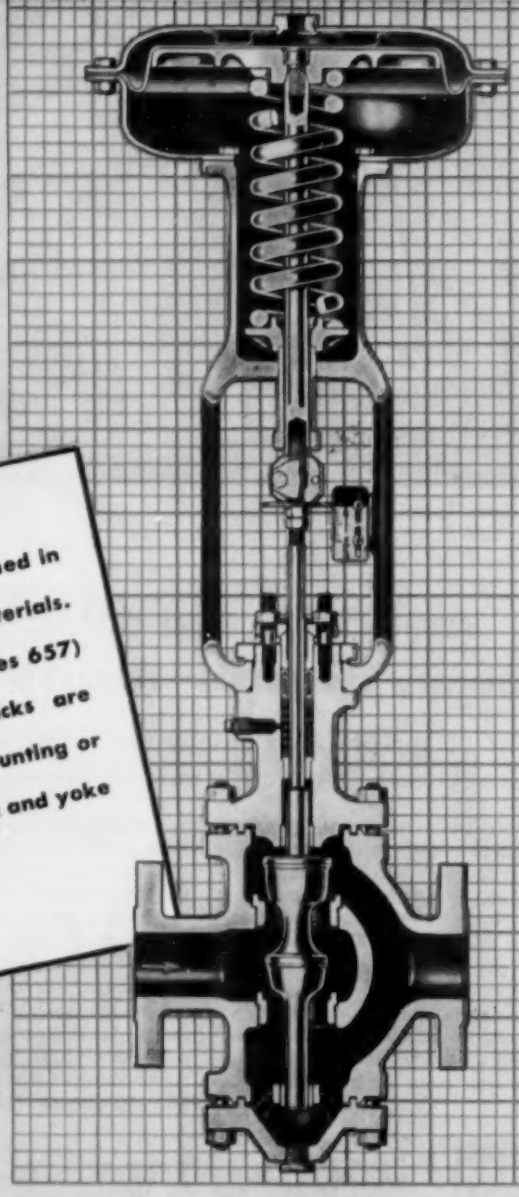
Johns-Manville *first-in* **INSULATION**

MATERIALS · ENGINEERING · APPLICATION

FISHER®

DIAPHRAGM





● Fisher Diaphragm Motor Valves are furnished in a wide variety of pressure ratings and materials. Topworks may be either direct acting (Series 657) or reverse acting (Series 667). Handjacks are available for either diaphragm casing mounting or yoke mounting. There are six diaphragm and yoke size combinations.

Improved

MOTOR VALVES

Improved PERFORMANCE FEATURES

- Bolted-clamp type stem connection allows stem adjustment of 50% of total travel. Can be disconnected in the field without stem damage. Will not shake loose from vibration or rotational inner valve forces.

- Rugged body to yoke connection with hammer lug nut. Topwork can be removed without disturbing stuffing box.

- Specially designed Buna N molded diaphragms with Nylon insert retain superior flexibility at low ambient operating temperatures. Provides linearity between operating pressure signal and travel, and gives maximum effective area.

- Bolted gland stuffing box with Teflon packing.

- Stainless steel clear view travel indicator.

- Spring ranges: 3 to 15 psi; 6 to 30 psi.

FISHER GOVERNOR COMPANY • Marshalltown, Iowa

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

FISHER

Since 1880

Business Investment Holds Key To Both Growth and Stability

What federal tax policy will best promote both growth and stability in the American economy? The Joint Economic Committee of Congress has been asking this crucially important question in public hearings. This editorial suggests one vital part of the answer.

The proposition advanced here is that—

> Tax policy must encourage a continuing high level of business investment in new plant and equipment, because such investment makes a special contribution to *both* economic growth and economic stability.

Growth Needed for Security

We must have both growth and stability.

A vigorous economic growth is essential to our national security. As Congressman Wilbur D. Mills said in launching the Joint Committee's hearings, "The present complexion of world affairs places a premium upon strength and growth in our national economy." Growth is likewise a major ingredient of a healthy domestic economy. Growing enterprises and growing communities offer far more opportunities for satisfying careers than those which are not growing.

A reasonably stable economy, without violent ups and downs, is also essential to our national welfare. Extravagant booms and their more or less inevitable result, severe depressions, waste labor and resources and cause great human misery. Both major political parties have accepted the obligation imposed by the Employment Act of 1946, that the federal government work to maintain high and stable employment.

There is general agreement that **the key to economic growth is investment in new plant and equipment.** Growth depends decisively on new facilities to increase production, and also to produce new and better products in new and better ways. At the same time, new plant investment provides employment for the important, and well-paid, one-fourth of our industrial workers who manufacture and build new production facilities. So if the process of business investment is kept on an even keel, the result is not only growth but also stability in a substantial sector of our economy.

But authorities disagree on the possibility of maintaining a high level of business investment for any great length of time. Some fear that it will lead to an excess of producing capacity and the glutting of markets, with recession or depression not far behind.

The history of our country offers some basis for the fear that it is dangerous to maintain a very high level of business investment. There have been times when the economy has suffered under the weight of excess producing capacity. **This fear, however, has been made obsolete by the recent course of our economic history which, in its earlier phases, nourished the fear.**

The World Has Changed

Here are some of the major considerations, cited at the Joint Committee hearings, which support the conclusion that we not only *can have* a high level of business investment and economic stability but that we actually *need* a high level of such investment to assure stability.

(1) Over the next 20 years our population is expected to increase by about one-third. But most of the population increase will come in age groups younger or older than normal working ages, and people will probably work fewer hours per week. Thus hours worked are not expected to increase more than 15%. Consequently, we must have a relatively large increase in the amount of production equipment per worker if our standard of living is not to suffer. This means a high level of new investment.

(2) About half of our present business investment goes to replace worn-out equipment, rather than to expand capacity as was true during the early stages of our industrial development.

(3) Thanks largely to the impact of organized research—for which we as a nation now spend about $4 billion a year—a large share of capital investment now goes to provide new products and new processes, rather than to expand existing capacity.

These developments make it unlikely that we shall develop the burden of excess capacity that plagued the economy in earlier periods. **Moreover, most capital investment plans are now made on a long-range basis. Companies are building facilities to anticipate their needs for several years ahead.** This increase in long-range planning has reduced the disturbing effects of temporary shortages and excesses in producing capacity.

The record of recent years speaks for itself. Business spending for new plant and equipment in 1955 was over $29 billion. This continued the high level of investment that has been maintained for the past ten years—a decade remarkable for both impressive growth and gratifying stability. A McGraw-Hill survey of preliminary plans for 1956 indicates another year of increasing investment, and expanding business activity.

Tax policy, to be successful, must consider this impressive contribution of business investment to both growth and stability.

Of course, the level of investment depends on many factors other than federal tax policy. The degree of business confidence is important. So is the strength of consumer markets. So is the attitude of organized labor toward the use of more efficient machinery. But tax policy is a crucially important factor. And it is becoming more so with new developments in our changing economy. These developments indicate that tax policy **must be geared to foster a high level of business investment, if the dual objectives of economic growth and economic stability are surely to be attained.**

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments that are of particular concern to the business and professional community served by our industrial and technical publications.

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Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY, INC.

EDITORIALS . . .

"Soyez les Bienvenus a Montreal au Mois de Mai!"

YOU'VE seen the statement above scattered throughout recent issues of PETROLEUM PROCESSING. Translated, it means "Welcome to Montreal in the month of May!"

All of which is by way of reminder that the 21st mid-year meeting of the API Division of Refining will be held in Montreal May 14-17.

From all indications, this will be one of the very best meetings the Division has ever held. We've just read through the preliminary program for it—and it's really a honey. The topics chosen for coverage, the papers to be presented during the 12 technical sessions, and the dinner meeting are all top quality. They are up-to-the minute in timeliness, being concerned with problems which are currently on top of the lists in the industry.

You can read all the details of what's on the program (at least to the extent that they are available at this date) in our Meetings section in this issue (pg. 167). But here are some examples of what we mean when we say it's a good program:

There's one session on processes which will be concerned solely with the general theme of octane numbers above 95. Five papers are planned. In addition to these, a special session not yet on the program but definitely scheduled for inclusion will take up the problem of how to measure octanes above 100. That's a problem which is becoming very real as motor fuels get closer and closer to the 100 octane "end point" on the currently-used scale.

Then there's a session on electrical equipment. Four papers are to be presented, each giving a view-point from a different source on reactions to the recently published API tentative standard RP-500. This standard spells out just what are the hazardous areas in a refinery or processing plant, and represents a long step forward in helping the industry know how to install electrical equipment. It was developed by the Refining Division's Subcommittee on Electrical Equipment after lengthy and intensive study.

This particular session will give the people at the Montreal meeting an opportunity to hear the reactions to working and living with RP-500 from a refiner, an engineering contractor, and an equipment manufacturer. In addition, there will be a discussion by a Canadian on the differences between electrical practices in his country and the U. S.

Still another important development in processing has been the growing interest in and use of computers. Here again the API Refining Division meeting planners have done some smart programming. A session at Montreal will include papers on the use of computers in operations planning, in heat exchanger design, and in calculating equilibrium composition.

These are only examples. The entire Montreal program follows the same pattern of top quality in all of the other sessions—on maintenance, corrosion, instrumentation, waste disposal, air pollution, fuels and lubricants, and training.

Our hats are off to Bill Gunn (director of the Division), his staff, and all the committee chairmen and members who developed this 21st mid-year meeting.

Don't miss it!

It's Nice to Be Friends

RECENTLY a legal spat between two of the leaders in the petroleum processing industry was settled amicably and out of court.

We're referring to the law suit between Houdry Process Corp. and Socony Mobil Oil Co., and involving mainly the TCC Airlift and the Houdiflow catalytic cracking processes. Managements of the two firms have approved an agreement which provides that:

1—The two companies will exchange full and complete immunities in the field of moving-bed catalytic cracking (including certain improvements in synthetic cracking catalyst, the so-called Houdresid technique, and the like) for their own operations and for those of their respective licensees, and the right to receive, use, and pass on to licensees technical information and know-how owned or controlled before Dec. 31, 1955 by either company.

2—The two companies will grant to each other for themselves and their respective present and future licensees an irrevocable non-exclusive royalty-free immunity under patent rights for certain inventions in the field of moving-bed catalytic cracking made during a five-year period beginning Jan. 1, 1956.

3—In acquisition of certain patent rights and in settlement of patent claims, Socony Mobil will pay $3-million to Houdry. In addition, with respect to any new TCC licenses granted by Socony during the five-year period beginning Jan. 1, 1956, Socony will pay Houdry $12.50 per bbl. of licensed capacity with respect to each paid-up license, and ¾¢ per bbl. out of running royalties received, until such payments amount to $12.50 per bbl. of daily capacity.

We're always happy when a dispute such as this one can be settled out of court. We think it shows good judgment on the part of both firms. It saves a lot of harsh words, costly legal fees, and bitter feelings.

Even more important, it clears the way for both companies to move ahead with their own respective developments in the processing field—without a cloud of legal uncertainty as to their patent standings.

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Above photograph courtesy of QUAKER STATE OIL REFINING CORP.

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Anhydrous Hydrofluoric Acid
Sulfuric Acid

POLYMERIZATION
Fluosulfonic Acid $HO{\cdot}SO_2F$
Boron Trifluoride
Sulfuric Acid

SULFONATION
Sulfuric Acid
Sulfan® (Stabilized Sulfuric Anhydride)
Oleum

ISOMERIZATION
Muriatic Acid (Hydrochloric)

DETERGENTS & BUILDERS
Sodium Metasilicate
Disodium Phosphate
Sodium Sulfate, Anhydrous
Trisodium Phosphate
Tetrasodium Pyrophosphate (TSPP)
Sodium Tripolyphosphate

ACIDIZING
Muriatic Acid (Hydrochloric)
Hydrofluoric Acid

MUD CONDITIONING
Sodium Silicate
Disodium Phosphate
Trisodium Phosphate
Tetrasodium Pyrophosphate (TSPP)
Sodium Tripolyphosphate

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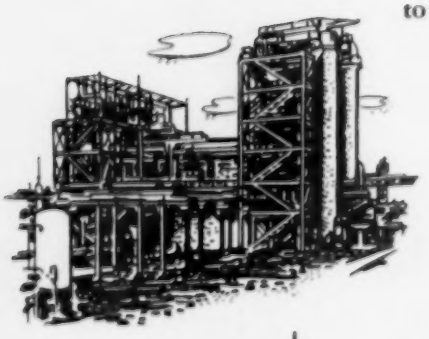
STABILITY

It is Wyatt's policy to maintain financial structure to match its plant structure. This surplus item in the assets column is in reality just another working tool.

As processing equipment becomes larger and more intricate, Wyatt's plants must be enlarged and fitted to meet their obligation. That is when a surplus ceases to be cash on hand and goes to work itself.

Putting some of the profit back in the business also gives a lift to employment, since men go to work as dollars go to work.



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